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FINAL REPORT ON THE NAVAL ACADEMY'S CAI PROJECT

by W.H. Sandeford and others

CAE
Computer Assisted Education
U S N A

United States Naval Academy

Annapolis, Maryland

PR-0571-43 February 1972

FINAL REPORT
ON THE
NAVAL ACADEMY'S CAI PROJECT,

by W.H. Sandeford and others.

A Subproject of Navy Research and
Development Program ADO 43-03X

Conducted by

EDUCATIONAL SYSTEMS CENTER
UNITED STATES NAVAL ACADEMY
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Submitted by:

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Director, Computer Services
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See over for a list of documents supplementing
this final project report.

FINAL REPORT PR-0571-43

Detailed information on the Naval Academy CAI Project reported here is available in the form of separately bound supplements, as follows:

SUPPLEMENT*

A - CAI-Teletype Project Report

B - Data Management Subsystem Report

C - Production of CAI Materials

D - CAI Project Facilities

E - Technical Recommendations by Consultants

F - Formative Evaluation of the CAI-1500 Project Materials

G - CAI-1500 Project Evaluation Report

H - CAI-1500 Chemistry Course Report

I - CAI-1500 Russian Course Report

J - CAI-1500 Naval Operations Analysis Course Report

K - CAI-1500 Modern Physics Course Report

*Abstracts of the Supplements are included here as Appendix A.

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13. ABSTRACT

Aimed at improving officer education through the use of modern technology, a two-pronged CAI effort was initiated in FY 67 at the Naval Academy and supported by the Bureau of Naval Personnel under the Chief of Naval Operations' Advanced Development Objective 43-03X, Education and Training. (A third project, Multi-Media Course Development, was funded separately by the U.S. Office of Education and reported (separately.)

CAI techniques and methods utilized in the dual projects (CAI-Teletype and CAI-1500) are discussed under three categories: computational, non-computational, and computer management of instruction.

Courses in science, engineering, and naval science were developed and tested in the CAI-Teletype Project which then went operational with 125 teletype terminals accessing a Honeywell (GE) 635 computer system.

The CAI-1500 Project featured sophisticated student terminals and utilized the IBM 1500 Instructional System in a more extensive, more tutorial manner aimed at replacing parts or all of conventional instructional in selected situations. Instructional modules were developed for four academic courses: General Chemistry, Modern Physics, Naval Operations Analysis, and Basic Russian I.

14. KEY WORDS	LINK A		LINK B		LINK C	
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CAI-1500 Project						
Validation						
Formative Evaluation						
Summative Evaluation						
Data Management						
Student Performance Analysis						
Student Attitude						
Time-sharing terminals						
COURSEWRITER II Programming						
Behavioral Science						
Modern Physics						
General Chemistry						
Operations Analysis						
Basic Russian I						

FOREWORD

Required levels of personnel readiness and capability in the Navy are dependent upon education and training programs. To achieve improvements in the Navy's education and training program, the Chief of Naval Operations established Advanced Development Objective 43-03X, Education and Training. A stated objective of the ADO was to "test the feasibility of available new advances in training technology . . . as a means for providing and maintaining increased personnel capabilities." Amplifying data contained in the basic ADO document identified a number of advances, already achieved under the research and exploratory development programs, sponsored by the Department of Defense and developed by various institutions, that were judged to be ready for feasibility testing under the advanced development concept. One of the technologies so identified was the "use of computer-aided and other automated techniques in instructional procedures and content."

Following the establishment of ADO 43-03X on 6 April 1966, several efforts in computer-assisted instruction were proposed. Because the ADO designated "Career Development Training for Line Officer" as a high priority substantive training area, a CAI effort was initiated at the United States Naval Academy, focusing on the development and utilization of computer-assisted instruction concepts and systems to improve the effectiveness of Navy officer education.

Another high priority area identified in the ADO was "Basic Electronics Training." An effort underway at the Naval Personnel and Training Research Laboratory, San Diego, is responsive to this requirement.

It is expected that these two projects will provide the information necessary for determining whether the systems and technologies evaluated should be accepted by the Navy for use in officer education.

ACKNOWLEDGMENTS

The supervision and management of this project was under the Director of the Educational Systems Center, Dr. Jesse L. Koontz, Assistant Professor on the faculty of the U. S. Naval Academy.

The Naval Academy acknowledges the support provided throughout this project by Dr. John J. Collins, Office of Chief of Naval Operations; Captain George F. Britner, USN, Mr. Allan S. Sjoholm, Dr. Martin T. Wiskoff, Dr. Norman J. Kerr, and Dr. Helen M. Flint, Bureau of Naval Personnel; and Dr. Victor Fields, Office of Naval Research.

Furthermore, numerous others contributed either directly or indirectly -- in advisory group meetings, organizational or institutional conferences, and personal discussions. Their contributions are also gratefully acknowledged.

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A. NAVY EDUCATION AND TRAINING

1. PURPOSE

Navy training supports the Navy's manpower and personnel management system -- an adaptive system, responsive to changing qualitative/quantitative demands for distribution and utilization, and to changing availabilities for input from different categories of manpower resources. Navy education and training, as a subsystem of the manpower and personnel management system, is expected to develop the capabilities of both on-board and newly procured personnel to meet the qualification requirements in widely diversified functional or occupational areas; in different degrees of specialization; and at all levels of proficiency.

2. NAVAL OFFICER EDUCATION

Each year the Navy commissions about 12,000 new officers to maintain the Navy to meet its present world-wide commitments, and to provide the experienced leaders needed for the Navy of tomorrow. Since the maximum number of officers the Navy may have is set by law, the number of new officers needed is determined by annual losses expected from retirements, releases from active duty, and similar attrition.

The Navy has a variety of programs to obtain new officers. They can be divided into three categories: long, medium, and short range. Long-range programs include the Naval Academy (USNA); the Naval Reserve Officers Training Corps (NROTC), both Regular and Four-year Contract; and the Navy Enlisted Scientific Education Program (NESEP). With the exception of the NROTC Four-year Contract program, these programs are designed to produce career officers, and their graduates are commissioned as Regular officers.

Medium-range programs, which are designed to produce Reserve Officers, include the NROTC Two-year Contract Program, the Reserve Officer Candidate Program (ROC), the Aviation Reserve Officer Candidate Program (AVROC), and the College Junior Program for women officer candidates.

Short-range programs include the Officer Candidate School (OCS), Women Officers School (WOS), Aviation Officer Candidate School (AOC), and Naval Aviation Officer Candidate School (NAOC). These programs produce Reserve officers, and all require that the candidates have baccalaureate degrees prior to enrollment. Since these programs are of relatively short duration, they can be expanded or contracted rapidly to meet changing requirements for newly-commissioned officers that result from changes in the world situation, the economy, and other factors. Hence, they are "safety valves" in officer procurement, that may be opened or closed quickly as conditions require.

3. IMPROVEMENT IN OFFICER EDUCATION

Technical advances have increased the complexity of the Navy's operational systems to such an extent that the command function has become correspondingly difficult. In order to meet this need for greater understanding, the naval officer requires a broad and comprehensive background with a firm foundation in mathematics, sciences, and engineering. Although the scope of knowledge to be mastered by the naval officer keeps increasing, the Navy must hold the line on the length of time and costs of naval officer education. The Navy anticipates that through its investment in advanced development research in education and training it can find techniques and methods that will improve the efficiency of its officer education programs.

The most commonly used instructional method in officer education, as in most college-level institutions, has been the traditional professor-lecture method. Though highly successful under some circumstances, it is generally recognized to have a number of limitations, including the following:

- It does not allow the student to proceed at his own individual rate of learning.
- It does not take into account individual differences in ability.
- It limits the practice that can reasonably be devoted to solution of complex problems.
- It is not conducive to course revision and updating because it gives little feedback as to the effectiveness of the material presented.

B. EDUCATION AT THE U. S. NAVAL ACADEMY

The United States Naval Academy is the undergraduate college of the U. S. Navy. Its primary mission is to prepare young men for professional careers as officers in the U. S. Navy or the U. S. Marine Corps.

Responsibility for directing the Naval Academy is vested in the Superintendent. He is assisted by the Commandant of Midshipmen and the Academic Dean. The Commandant is responsible for directing the military and physical training of midshipmen, while the civilian Dean supervises the academic curriculum and academic standards. The academic organization consists of five Academic Divisions, each headed by a Navy captain who reports directly to the Dean. The Divisions, in turn, are subdivided into the following 19 academic departments, the chairmen of which may be either a civilian professor or a Navy or Marine Corps officer:

- Division of Engineering and Weapons

  Aerospace Engineering
  Electrical Engineering
  Mechanical Engineering
  Naval Systems Engineering
  Weapons and Systems Engineering

- <u>Division of Mathematics and Science</u>

  Chemistry
  Computer Science
  Environmental Science
  Mathematics
  Physics

- <u>Division of Naval Command and Management</u>

  Behavioral Science
  Management Science
  Navigation
  Semanship and Tactics

- <u>Division of U. S. and International Studies</u>

  Area-Language Studies
  Economics
  Political Science

- <u>Division of English and History</u>

  English
  History

In support of the primary mission, the basic portion of the curriculum has been developed to provide each midshipman with skills and knowledge necessary for the performance of his duties as a junior officer. This requirement is met through a sequence of professional/academic courses and two summer at-sea training cruises. Emphasis is placed on seamanship, navigation, engineering, and weaponry. Another portion of the basic curriculum provides all midshipmen with a broad liberal education in social science and humanities with a fundamental background in mathematics, science, and engineering. A final portion of the curriculum is devoted to an elected major that provides the opportunity for in-depth study in a field of interest.

The 26 majors offered include aerospace engineering, electrical engineering, mechanical engineering, marine engineering, naval architecture, ocean engineering, systems engineering, general engineering, mathematics, chemistry, oceanography, physical science, bioscience, physics, analytical management, operations analysis, European studies (French, German), Far Eastern studies, Latin American studies, Soviet studies, economics, American political systems, international security affairs, English, and history.

Under the Academy's Trident Scholar Program, a limited number of exceptional students are selected to pursue independent study and research projects of their choosing during their senior years. Each scholar has a faculty advisor. Scholars carry a reduced number of courses, and their research and thesis constitute the major part of their academic program for the year.

In order that a midshipman qualify for graduation he must satisfactorily complete the required professional courses and other specifically required courses, as well as the general distribution requirements in humanities/ social science, mathematics, science, modern languages, and computer science, and finally the major course requirements. He must satisfactorily complete, or validate, a minimum of 140 semester hours of acceptable academic courses and achieve a cumulative Quality Point Rating of at least 2.0.

In addition to meeting the academic requirements for the degree, a midshipman must meet required standards of performance in the military and professional area, including at-sea training, aptitude for the service, conduct, and physical education.

Upon the satisfactory completion of all requirements, graduates of the four-year program are awarded the Bachelor of Science degree and if in an engineering discipline, the degree is so designated--for example Bachelor of Science in Aerospace Engineering.

The overall academic program is supported by approximately 500 course offerings of which slightly more than 200 are offered each semester, including some of graduate level. In addition, the academic program for the 4200 midshipmen is supported by a faculty of 540. Military and civilian members of the faculty are assigned to academic departments in accordance with their individual backgrounds and talents. For example, the Seamanship and Tactics Department is staffed by officers, whereas the Area-Language Studies is largely civilian faculty. The Academy's balanced officer and civilian faculty is unique to the service academies. The officers, rotated at intervals of two and three years, provide a continuing input of new ideas and experience from the Fleet. The civilians provide a core of professional scholarship and teaching experience as well as continuity to the Academy's educational program.

Although an average class size is 20 students, there are courses which lend themselves to large sections of 60 to 80 students, while a number of elective courses have an enrollment of only 10-15 students.

It is interesting to note that, although the faculty devotes a considerable amount of time to the academic counseling and individualized tutoring of midshipmen, especially those in academic difficulty, the attrition rate, which is generally near 30 percent, is like that at many other academic institutions.

The 1300 young men who are admitted to the plebe class each year come from every state in the Union and from backgrounds reflecting every facet of American life. Each candidate must meet general eligibility and physical requirements. In the final selection of candidates who are competing for appointments, the Naval Academy takes into account the quality of the secondary school record, additional study, the College Board or ACT scores, extracurricular activities, athletics, honors and awards, employment outside school hours, recommendations of teachers, guidance counselors, principals, coaches and others who know first-hand the candidate's accomplishments, his potential, and his motivation for a career in the Naval Service.

C. EDUCATIONAL TECHNOLOGY PROJECTS AT THE NAVAL ACADEMY

Three projects -- all aimed at improving officer education through the use of modern technology -- have been conducted at the Naval Academy by the Academy's Educational Systems Center. They are designated as: The CAI-Teletype Project; The CAI-1500 Project; and The Multi-Media Course Development Project.

The first two projects were initiated in 1967 and supported by the Bureau of Naval Personnel under the ADO 43-03X program. The Multi-Media Project was funded by the U. S. Office of Education.

This report is concerned only with the two CAI projects (CAI-Teletype and CAI-1500) conducted under ADO 43-03X. These two projects concentrated on developing and evaluating the use of computers as an instructional tool -- computer-assisted instruction, or CAI.

The goals of this effort were to alleviate some of the problems, enumerated earlier in this chapter, by demonstrating the use of the computer to:

- Individualize instruction
- Facilitate the solution of complex problems
- Aid in determining optimum course content
- Record and analyze student performance.

(The Multi-Media Project also included some elements of computer-assisted instruction. Information on that project is available through ERIC -- Educational Resources Information Center, U. S. Department of Health, Education, and Welfare.)

D. CAI TECHNIQUES AND METHODS

In the context of this project, Computer-Assisted Instruction is defined as the utilization of computers as an integral part of the learning process. While it is useful to distinguish between student-authored and professor-authored programs and between tutorial and non-tutorial techniques (such as simulation, gaming, data reduction), all of these are viewed as being within the domain of CAI. CAI techniques and methods are discussed under three categories: (1) computational, (2) non-computational, and (3) computer management of instruction.

1. COMPUTATIONAL TECHNIQUES

a. Simulation

Computer simulation of laboratory exercises and other real world situations represents a significant CAI technique. In this situation a mathematical model is generated which simulates the real life occurrence of a particular environment and allows the student to interact with the model. A simulation can also be a group classroom demonstration which is integrated into the traditional instructional setting. This technique can provide learning experiences to students that might not otherwise be available because of factors such as safety, equipment cost or availability, prohibitive set-up time, or other factors of cost or convenience.

Because of such constraints, it has often been impractical to give each student hands-on exposure to every "system" he will encounter in his studies. Therefore computer simulations make a very valuable contribution by circumventing these constraints and putting in the student's hands the complicated "thing" his instructor and textbook have been endeavoring to describe to him.

b. Problem Solving

Problem-solving refers to the use of a computer to solve quantitative problems, and the student uses a language like FORTRAN or BASIC to accomplish his purpose. He writes a program and enters his data. In this mode the computer is used to do what it is primarily designed to do. A problem often loses its significance when over-simplified to permit a solution within a reasonable period of time. Through remote time-sharing and simplified programming language, the potential of this technique as an educational device is realized.

In addition to allowing for efficient solution of complex problems the remote time-sharing system permits the student to learn as he performs, since on-line debugging is accomplished without delay or loss of problem continuity.

c. Data Reduction and Formatting

Although this mode of CAI might be considered a subset of simulation and/or problem solving, it is significantly distinct to warrant separate discussion. Data reduction and formatting involves collecting information in raw data form and, after simulation or problem solving, formatting the output. Essential to a laboratory exercise, for example, is the student's ability to perform the experiment and accurately collect information in raw data form. The raw data must be interpreted, and this may require mathematical calculations as well as the construction of graphs or tables before an analysis and conclusion can be made.

2. NON-COMPUTATIONAL TECHNIQUES

a. Drill and Practice

Drill and practice is the use of a computer to present learning materials, such as language drills and problems in arithmetic, which utilize the same sequence and format. The instructional strategies are usually quite simple, as the computer is used to provide practice in particular concepts and diagnose a student's weaknesses. There are basically two types of drill and practice exercises. The first consists of practice problems and routines that are designed by the course author, generated by the instructional program, and presented to the student via the computer terminal. The second type of drill and practice exercise is substantially different as the student is allowed to generate his own problem set. Such an exercise provides the student with the opportunity to construct his own problem set and input data and to respond with his solution to the practice problem. The computer calculates the correct answer and compares it to the student's response. The instructional program may branch the student to particular additional problems, to remedial sequences; or it may suggest the student construct a particular kind of problem or one of increased difficulty.

b. Tutorial

Tutorial instruction is a level of instruction that not only involves dialogue but also the other modes. For example, the consequences of a student's response to a question may be drill and practice, or it may be a simulation, etc. This technique is characterized by (1) the presentation of learning material to the student in various step sizes, (2) a question or test item, and (3) evaluation of the student's response, reinforcement, and/or branching to another section of the instructional program. Essentially, there are two basic formats in which the tutorial technique is presently being used in CAI lesson design. The first consists of a "complete" tutorial dialogue between the student and the computer. This is to imply that all information, concepts, and learning materials are presented to students via the CAI terminal; and no "off-line" methods are used. The second type of tutorial lesson is referred to as a "partial" tutorial dialogue. The student's initial exposure to the material to be learned is from an off-line source, such as a traditional lecture, ETV, or reading material.

c. On-Line Testing

Another basic CAI technique is testing. This technique can be applied either as a stand-alone application or, as most frequently occurs, in combination with one of the other basic techniques. There are numerous methods of applying the testing technique to CAI instructional strategies. Measures of student attainment of specific objectives, diagnostic testing for remedial sequences, curriculum validation criteria, and administrative testing are some applications of the testing technique.

3. COMPUTER MANAGEMENT OF INSTRUCTION (CMI)

The use of computers as a management tool is a broad and important topic. The primary function of the computer is to assist the administrator, curriculum developer, researcher, teacher, and student in the planning, development, and prescription of instruction. Owing to the particular goals and limitations in this project, the full potential of this area was not investigated. Emphasis was placed mainly on the management of student data for course revision, development of remedial sequences, as well as data reduction and reporting for evaluation of students and materials.

4. CAI CLASSIFICATION PROBLEMS

It is evident from examining the foregoing discussion of the six techniques that CAI materials generally cannot be classified according to one specific technique for at least two reasons:

- First - A considerable amount of quality CAI material resists being fitted neatly under one heading, but rather has elements of several. For example: an effective simulation may begin with a pre-test used both for evaluative and prescription purposes; since unguided discovery learning is frequently unproductive, certain hints, diagnostic routines, and tutorial remediation may be incorporated; depending on the complexity and options for data printout, extensive use may be made of statistical and graphic routines; and finally, to insure that the student accomplishes the objectives set for the simulation, tutorial routines may be used to probe the student's "understanding" in the context of the simulation (which may involve complex problem solution where the student modifies equations or sets up his own mathematical models for testing).

- Second - The manner in which the CAI materials are used is a critical dimension of importance both for design and evaluation. A simulation, for instance, may be utilized: (1) to introduce a concept area, (2) to introduce a laboratory session, (3) to replace a laboratory, (4) as a classroom demonstration, (5) as part of a review package, or (6) as a homework exercise.

E. STAFF ORGANIZATION

From late 1966 till mid-69, the CAI projects were carried out by the Academic Computing Center. At that point, the staff associated with the developmental aspects (as opposed to operational) of the CAI and Multi-Media projects was formed into a separate organizational entity titled the Educational and Management Systems Center. Shortly thereafter (about the spring of 1970), the name was simplified and changed to EDUCATIONAL SYSTEMS CENTER (ESC) which is the term used throughout this report. The general organizational structure is depicted in Figure 1.

F. THE OPERATIONAL ENVIRONMENT AND CONSTRAINTS

Brief mention should be made of the constraints experienced in performing research and development in an operational environment. Similar circumstances are faced by anyone conducting long-range research in an ongoing, dynamic institution, such as the Naval Academy, whose primary purpose is something other than research. Yet, too often, these factors are not anticipated in the research planning phase nor are they given any weight in the interpretation of research findings.

1. CURRICULUM REVISIONS

Curriculum change during the course of a long-range project is almost inevitable. For example, the majors curriculum was inaugurated at the Naval Academy in September 1969 for the three lower classes. The Class of 1970 had gone too far with the old program to shift over. By September 1970 all four classes were enrolled in the new curriculum. This had a serious effect on the CAI-1500 Project, particularly in the Russian and Physics courses.

2. FACULTY ROTATION

Faculty changes occurred, too, as the result of the rotation of military personnel serving as instructors, and the inevitable shifts

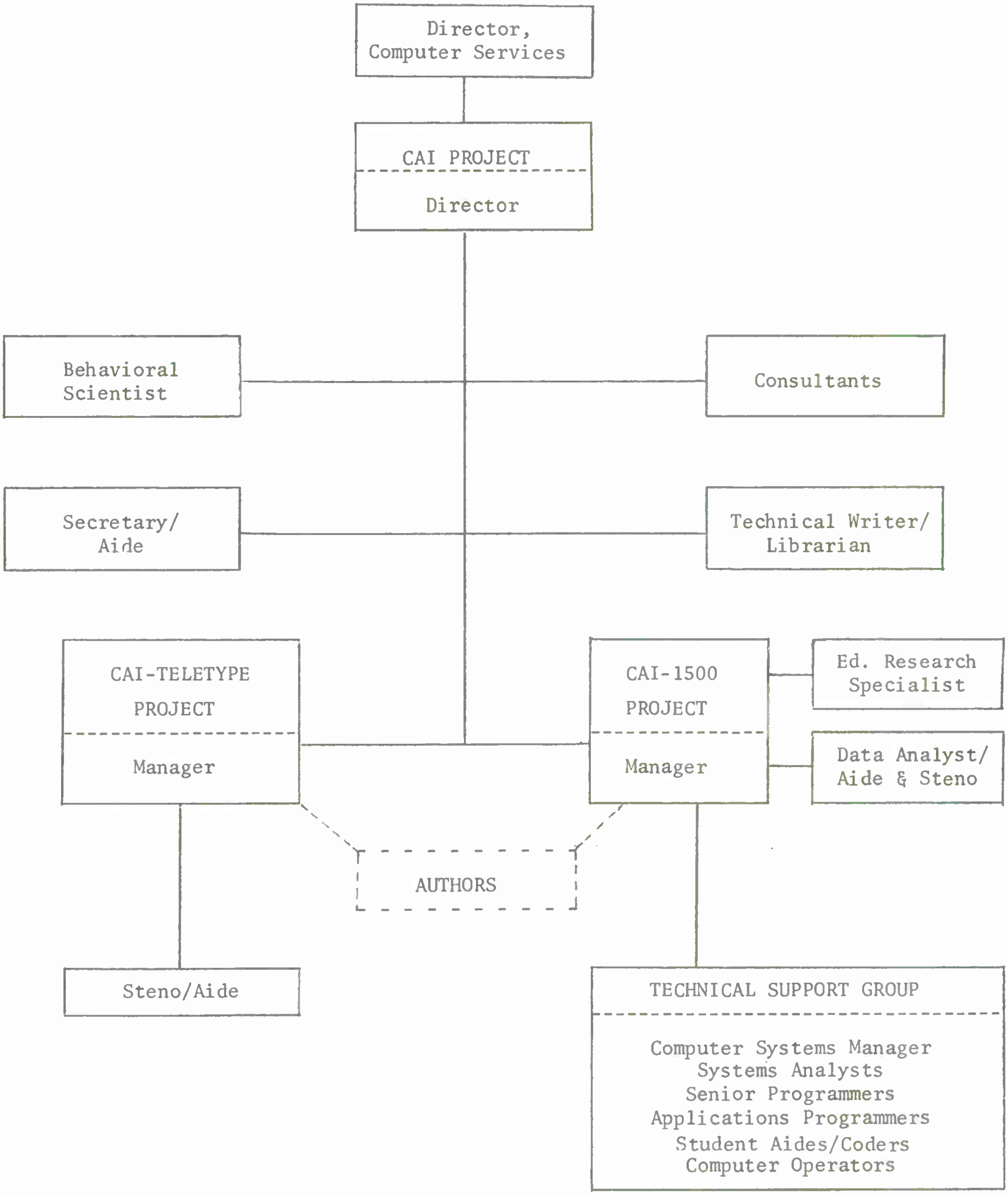

Figure 1. STAFF ORGANIZATION, EDUCATIONAL SYSTEMS CENTER

in civilian personnel who change jobs, retire, or die. In both the CAI-1500 and CAI-Teletype projects, instructors who had worked closely with the projects at the beginning were no longer at the Academy when the projects terminated. In a number of cases, those who had participated in the initial orientation sessions, prior to the actual initiation of the CAI projects, were not the instructors who worked most closely with the projects during their later stages. In the concentrated effort to complete the project, there was little time for indoctrinating the newcomers, with the result that adequate data was not always obtained. For example, some instructors neglected to obtain both pre- and post-test results, and so some course materials could not be evaluated adequately.

3. STUDENT ENVIRONMENT

Perhaps even more important than the curriculum and faculty changes were considerations pertaining to students. The Naval Academy, with its relatively small classes and individual student counseling, makes a special effort to keep the attrition rate to a minimum, to see that its highly selected students complete the four-year course successfully. Consequently, during the life of the CAI projects, the directors made a special effort to ensure that students were not being used as "guinea pigs," and that, despite their tight schedules and heavy academic loads, they suffered no loss in time or effort as a result of their participation in the projects. Sometimes this was carried to extremes, particularly by instructors who felt compelled to provide special instruction to students in the experimental group who, according to the research design, were to learn the material via the computer in a tutorial mode.

Despite constraints such as those just noted, the Educational Systems Center was provided the necessary support to conduct these projects, and numerous individual members of the Naval Academy faculty gave generously of their time and talents (Appendix B). The Naval Academy CAE Advisory Board met in Annapolis on several occasions to review the progress of the projects (Appendix C).

G. PROJECT FACILITIES

This section provides an overview of the facilities used in the Naval Academy CAI projects. For a more detailed description, the reader may refer to Supplement B (Data Management Subsystem) and Supplement D (CAI Project Facilities).

1. THE CAI-1500 PROJECT

Throughout the life of the CAI-1500 Project, Ward Hall housed the IBM 1500/1800 system. (See Figure 2.) Student terminals were located in an adjoining two-story frame building. Originally, the first floor of this building provided the necessary space for a 12-carrel classroom (Figure 3), a Resource Center, a teletype terminal, and engineering and duplicating equipment. Staff offices and a keypunch occupied the second floor. In the spring of 1969, a second 12-terminal classroom was installed on the second floor of the building and the staff offices moved to nearby Dahlgren Hall. The IBM 1500 system, including its maintenance and support of all IBM software, was leased from IBM by the Naval Academy. At the time of its installation at the Academy, there were relatively few such systems available, and the CAI state-of-the-art was in its infancy. The system had been designed for instruction and proved to be capable of providing a wide range of instructional conditions when a variety of instructional devices were added.

The system consisted of: (1) equipment and (2) programming systems.

a. Equipment

Included here are an 1802 central processing unit (CPU), a 1442 card read/punch, a 1443 line printer, a 2310 disk storage unit, a 1502 station control, and 27 instructional stations.

Each station could be used in any one of three modes: author, proctor, or student. Devices IBM offers for station use include a 1510

Figure 2. "THE MACHINE ROOM," SHOWING IBM 1802 CENTRAL PROCESSING UNIT AND PERIPHERAL EQUIPMENT

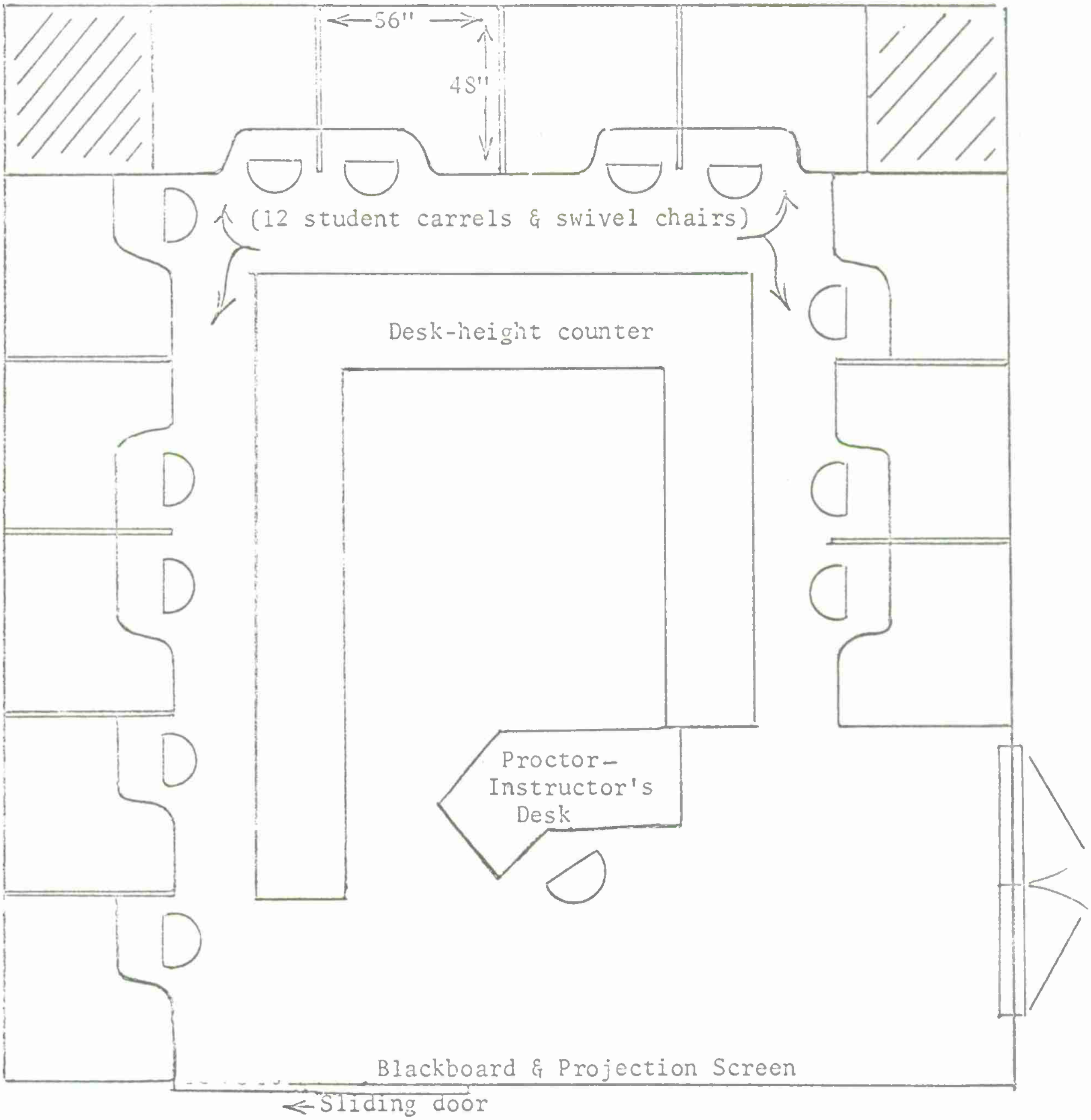

Figure 3. ONE OF TWO CAI-1500 EXPERIMENTAL CLASSROOMS

instructional display (with keyboard/light pen) containing a CRT for display of alphabetic and numeric characters or images; a 1518 typewriter; a 1512 image projector; and a 1506 audio unit. Figures 4 and 5 show the station and classroom in use.

b. Programming Systems

These include (1) an operating system which supervises all operations performed by the equipment and certain other CAI programs; and (2) the COURSEWRITER II language. These are supported by background application programs and utility programs that perform service functions such as printing lists of performance records and student records.

Additional programming systems available for the 1800 version of the IBM Instructional System include the Time-Sharing Executive System (TSX) and the 1800 card/paper tape programming system. While these did not support instruction directly, they were important for data management.

2. THE CAI-TELETYPE PROJECT

The CAI-Teletype Project required space only for the teletype terminals because time-sharing computer support was provided by vendors at remote locations. The number of terminals grew from five in 1966 to 40 in 1970. After the Honeywell (GE) 635 system was installed at the Academy and became operational in January 1971, it provided the necessary computer support in-house, thereby eliminating the need for vendors. The GE-635 occupies a computer room (about 2000 square feet) in Ward Hall. Teletype terminals (currently 125) are located mainly in special classrooms in the same building; others are at various locations at the Academy.

The Honeywell (GE) 635 system was specifically configured to serve the Naval Academy's academic needs and to parallel the Dartmouth system in order to operate with the Dartmouth time-sharing software (DTSS). It handles programs written in BASIC, FORTRAN, ALGOL, COBOL, LISP, TRAC, LAFF, JOVIAL, MIX, SIMSCRIPT, and computer languages appropriate to the operating system in use.

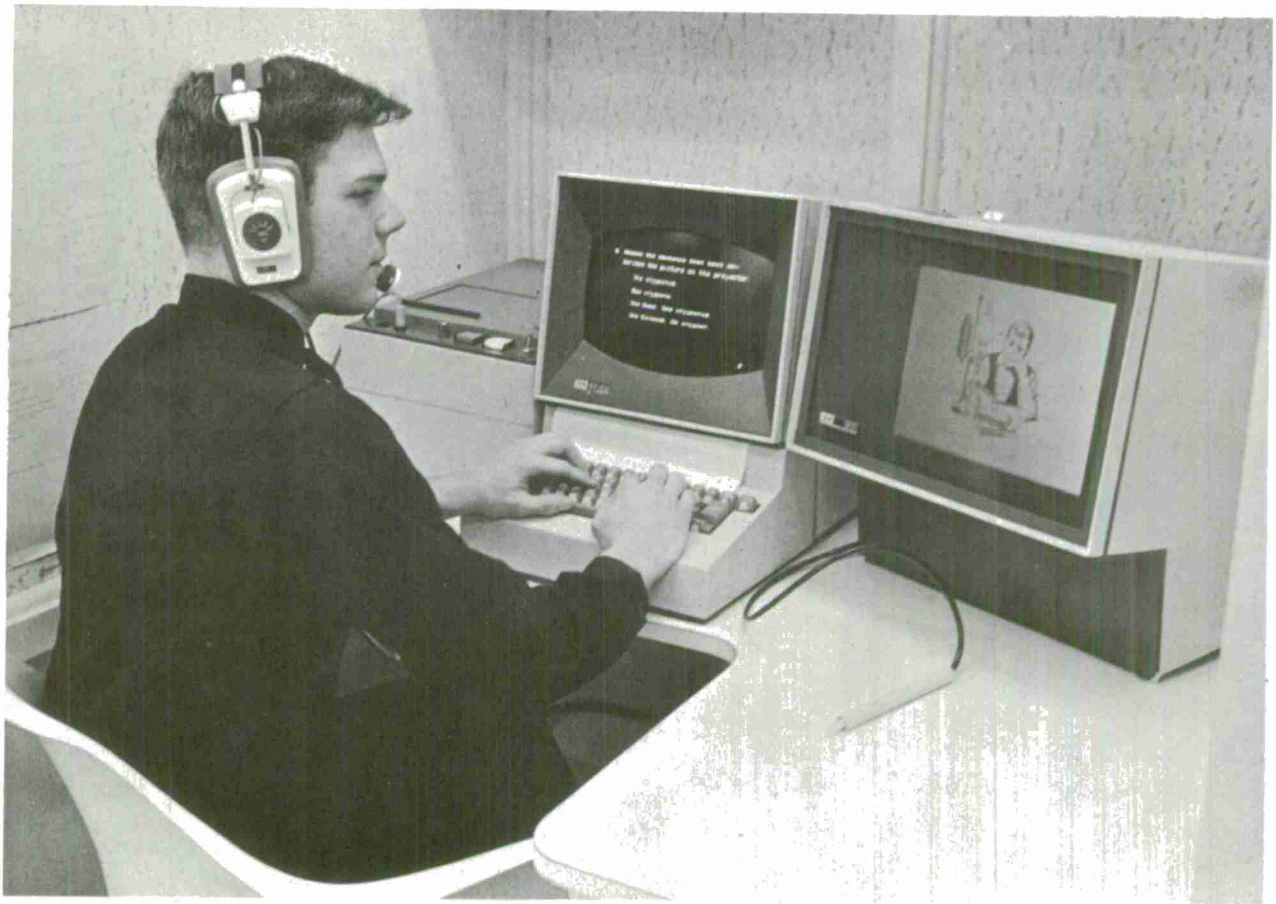

Figure 4. STUDENT INSTRUCTIONAL STATION SHOWING THE 1500 INSTRUCTIONAL DISPLAY, IMAGE PROJECTOR, AND AUDIO UNIT

Figure 5. STUDENTS AT CAI-1500 INSTRUCTIONAL STATIONS

3. RESOURCE CENTER

A Resource Center was established in June 1967 with funds from the Office of Naval Research (ONR). Its purpose was to find a means of providing library support to development programs in Educational Technology. Originally it focused on the effective collection and dissemination of information helpful to user groups at the Naval Academy. In time, however, its functions became much broader, and it performed many-faceted service and public relations functions. For example, an information exchange with about 85 other educational research projects throughout the world was initiated; a workable storage and retrieval system utilizing a time-sharing computer functioned as a pilot study of keyword search in retrieval of reports, papers, and other materials not included in books or periodicals. This Center occupied a space of 19 by 17 feet in a room adjacent to the first-floor CAI-1500 classroom.

II. THE CAI TELETYPE PROJECT

A. INTRODUCTION

This project takes its name from the type of terminal used by the student to communicate with the computer, namely, the standard Model 33 (or 35) teletypewriter, as shown in Figure 6. A number of courses in science, engineering, and naval science were selected for development and testing of the following CAI techniques: (1) Tutorial, (2) Simulation, (3) Drill and Practice, (4) Data Reduction, and (5) Problem Solving. Because of such limitations as program size, speed of terminal output, and the like, the techniques examined in this project were predominantly computational. Early identification of successful methods led to adoption of many of the CAI materials as an operational part of instruction, thereby initiating a period of still active growth of academic use of computers at the Naval Academy and enthusiastic faculty involvement.

The CAI-Teletype Project proceeded through four stages which have been labelled: spot-testing, implementation, validation, and evaluation. Each stage had a duration of one year (determined by the Naval Academy semester system). Midway through the project, transition from experimental to operational status occurred for several of the CAI courses. This transition was accompanied by a sharp increase in faculty and administration interest in the use of computers for instructional purposes.

A detailed description of this project is contained in Supplement A (CAI-Teletype Project Report).

B. SPOT-TESTING STAGE

The potential for increasing the effectiveness of officer education became evident to faculty members involved in the ONR-sponsored feasibility and appreciation study.* A decision was made to capitalize on the enthusiasm

*U.S. Naval Academy Feasibility and Appreciation Study of Remote Terminal On-Line Computing in Education, Academic Computing Center, U.S. Naval Academy, Annapolis, Maryland, October 1966.

Figure 6. ASR-33 TELETYPE CONSOLE WITH A PAPER TAPE PUNCH/READER

and experience gained during this study as early as possible but in a modest way. Specific situations were selected in a number of courses where CAI techniques could be spot-tested.

The spot-testing program was both primitive and limited, in that psychometric scales were not used nor were all possible parts of the course included. Nevertheless, it was considered a necessary step in determining not only the feasibility of using remote terminals on-line for computing in Naval Academy classrooms but also assessing the reactions and observations of the faculty to these spot applications. Other important aims were (1) to explore directions to be taken for the most effective use of CAI, (2) to acquire first-hand knowledge of the most useful applications that might be employed, and (3) to learn some of the drawbacks or hindrances that might be overcome in advance of further effort. It was expected also that this program would enhance the management's ability to make realistic time and cost estimates in this area.

1. HYPOTHESES

In general, it was hypothesized that the use of remote terminals in the classroom and laboratory would contribute to improvements in one or more of the following three areas:

- The time required to deal with certain materials.
- The depth to which certain materials may be treated.
- The length or number of items or topics which may be treated.

These three areas were further subdivided, and the following specific hypotheses were advanced. Namely, it was theorized that the use of remote terminal computing in the classroom and laboratory would:

- Increase student interest, even among the poorer students.
- Increase student participation, even among the poorer students.
- Obtain favorable student reaction.
- Obtain favorable faculty reaction.

- Reduce calculation and problem solution time, thus allowing more formal instruction or investigation time.
- Allow the demonstration and manipulation of complex equations and difficult concepts which were heretofore impossible in the classroom.
- Allow the assignment of more complex problems for the student to solve.
- Allow simulation of laboratories where dangerous situations exist, continuous data under adverse conditions is desired, or repeated runs with student control over parameters is desired.
- Allow use of analytical methods and data reduction which were not feasible previously.

2. COURSES AND TECHNIQUES SELECTED

For detailed information of the techniques and findings, see the Spot-Testing Report*. Briefly, the courses and types of techniques utilized were as follows:

- Chemistry -- Laboratory simulation
  - -- Drill and analysis
  - -- Testing
  - -- Laboratory data reduction
  - -- Classroom simulations of complex systems
- Operations Analysis -- Classroom simulation
- Engineering -- Classroom demonstrations
  - -- Data reduction
  - -- Design problems
  - -- Laboratory simulations
  - -- Testing
  - -- Drill and analysis
  - -- Limited tutorial

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*Report on Spot Testing of Computer-Assisted Education, No. PR-0767-3, Academic Computing Center, U. S. Naval Academy, Annapolis, Maryland, December 1967.

- Underwater Acoustics -- Problem solving simulation
- Physics -- Laboratory simulation
  - -- Laboratory data analysis
  - -- Drill and analysis
  - -- Limited tutorial
- Linear Systems -- Classroom presentation of dynamic motion
- Weapons and Control System -- Classroom demonstration of complex solutions

3. SUMMARY OF RESULTS

A matrix of results showing by course where a positive result was obtained for each of the major hypothesis is provided in Figure 7.

While the most frequently used technique was classroom demonstration (simulation), most faculty and student comments indicated that increased direct student interaction with the terminal would be very desirable. To accomplish this, the number of teletype terminals available for use needed to be increased.

C. IMPLEMENTATION STAGE

1. OBJECTIVES

The purpose of this stage was to capitalize on the more promising techniques and experience gained in the previous stage. By expanding the number of faculty members/courses and the quantity of CAI material and by using these CAI materials with full classes of students -- that is, "implementing" CAI into the formal curriculum -- it was expected that this stage could yield more specific, objective data regarding CAI feasibility. Additionally, the implementation stage was intended to provide a basis for a more formal and penetrating study of CAI which was to follow.

Broad objectives of the CAI-Teletype Project were:

- To provide the faculty with an appreciation for and a skill in the application of time-sharing computers as a learning device.

Courses

Physics	Linear Systems	Weapons Systems	Chemistry	Operations Analysis	Engineering	Underwater Acoustics	Hypotheses (See pages 24-25)
X	X	X	X	X	X	X	increased student interest
X	X		X		X		increased student participation
X	X	X	X	X	X	X	favorable student reaction
X	X	X	X	X	X	X	favorable faculty reaction
X			X		X	X	reduced calculation time - more instruction time
	X	X	X	X	X	X	demonstration and manipulation of complex equations and concepts
			X		X	X	assignment of more complex problems
X	X	X	X	X	X	X	use of analytical methods and data reduction not previously feasible

(X = favorable results)

Figure 7. MATRIX OF RESULTS BY COURSE OF SPOT-TESTING FOR CAI-TELETYPE

- To develop effective teaching techniques in using remote computer terminals.
- To implement CAI effectively into the Naval Academy curriculum.

The first two objectives are really never-ending because awareness of the computer's potential continually spreads. However, practically speaking, these first two objectives were met with respect to the project as pointed out in the Spot-Testing Report. It is toward the third objective that the attention of the implementation stage was directed. Both faculty enthusiasm and know-how were available. The problem was to determine how the remote computer terminal, as an instrument of learning, could be profitably implemented into the curriculum.

The first two objectives were accomplished with minimal facilities, that is, nine teletype terminals distributed singly among many disciplines. This would not accommodate much student usage. Therefore, a sub-objective became the determination of what facilities were required and how to maximize terminal availability -- availability to students in the classroom, in the laboratory, and at unscheduled times. Individual faculty members must determine whether valuable classroom time could profitably be devoted to on-line activities or whether outside classroom hours should be utilized instead. The type of course being considered has a direct effect on this determination.

Another sub-objective emanated from this decision, which is that the administrative procedure involving student use of teletype terminals must be described. Such things as scheduling, grading, and handling of hardcopy printout material must be understood. Additionally, the instructor must have a feeling for what benefits his students might be expected to derive from the CAI aspects of his course. (Refer to hypotheses listed previously on page 24.)

2. RESULTS OF THE IMPLEMENTATION STAGE*

There was no question that the problem solution and simulation techniques (both in and outside class) were extremely powerful. Although new and certain to undergo considerable refinement, these techniques were already accepted by a large group of science and engineering professors including many who were not part of the CAI-Teletype Project. Inasmuch as a decision had been reached to make these techniques an operational part of many Naval Academy courses and to provide operational funding for this purpose, further formal investigation of the techniques was not warranted. Moreover, the increase in scope and depth of the courses using these CAI techniques was so great that experimental comparison with the conventional counterparts could not be justified. A particular case was the Aerodynamic Performance Laboratory which became operational in 1969-1970. The basis for the decision to go operational included the following observations:

- Student attitude was overwhelmingly positive. The few negative comments regarding computer use pertained to the pre/post-tests and to poor computer system performance.
- Many students elected to make use of computer (not required) in solution of their term problems.
- The computer utilization was much higher than required: 1198 hours were used, whereas 486 hours were required.
- Laboratory experiments were substantially enriched and expanded.
- The ease of learning and using the BASIC language greatly facilitated faculty and student generation of programs. (Approximately 200 hours were expended by faculty members in developing the CAI programs.)
- The computer was very effective in teaching parameterization and optimization techniques.

Drill and analysis and tutorial techniques remained suspect, however. It was concluded that a more thorough measurement of the effects of these techniques on student learning was necessary.

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*Report on the Implementation of Computer Assistance in Education, No. PR-0169-14, Academic Computing Center, U.S. Naval Academy, Annapolis, Maryland, September 1968.

D. EVALUATION OF SPECIFIC COURSES USING DRILL AND ANALYSIS/ TUTORIAL TECHNIQUES

Three courses selected from the implementation stage underwent critical analysis and revision based on student data which was collected the previous year. The validation testing of these CAI courses occurred during the academic year 1968-69, and they were further refined and tested according to a formal research design during academic year 1969-70. A description of the CAI techniques, the findings, and the conclusion pertaining to each of these courses may be found in Supplement A (CAI-Teletype Project Report). A summary of evaluation results is provided below.

1. PHYSICS

The CAI group consisted of 15 students, and their performance on the final exam was compared with the performance of 237 students who received only conventional instruction. The mean score for the CAI group was 32.3, and the mean score for the control group was 35.2. The difference between these means was at a statistically low level of significance (.10; which means that this difference could have occurred ten times out of 100 by chance). However, when the two groups were equated with respect to several student aptitude and interest variables, there was no statistically significant difference between them.

2. ELECTRICAL SCIENCE

Two separate control groups were used in the evaluation of the Electrical Science materials. The first control group (with 43 students) received a portion of the CAI materials in printed form, and the second control group (with 19 students) received only the conventional instruction. There were 38 students in the CAI group. The mean score on the final exam for the CAI group was 55.6, the first control group's mean score was 54.6, and the second control group's mean score was 52.8. When these three groups were equated with respect to variations in student background and aptitudes, no statistically significant differences were found among the groups on final examination performance.

3. MECHANICS OF MATERIALS

A serious constraint was unintentionally placed on evaluation of the CAI materials for the Mechanics of Materials course by the Naval Academy because of a recent curriculum change. As a result of this change, only eight students took the course, so no control group taking the course concurrently with the CAI group was available. Due to the lack of a formal control group, only loose comparisons of the CAI class can be made with general performance levels of 16 students in prior semesters who were taught by the same instructor teaching this single section of eight students.

The mean final exam grade for the CAI group was 2.50, and the group designated as the control group had a mean final exam grade of 2.69. As with the other two courses, when various student aptitudes were equated across the CAI and control groups, no statistically significant differences were found.

E. PROBLEMS OF EVALUATION

1. COURSES BECAME OPERATIONAL

Probably the most important factor is that the formal evaluation was limited to the three teletype courses which did not change over from research funding to operational funding. It can reasonably be assumed that the CAI materials developed for these three courses were the least desirable, as far as faculty opinion is concerned, of the materials developed for 12 courses since they were never considered ready for operational use. If this is the case, then, this evaluation is not representative of the effectiveness of all CAI-Teletype materials developed at the Naval Academy.

2. HARDWARE/SOFTWARE PROBLEMS

A second factor is that the effectiveness of the materials was probably reduced considerably by the many computer system problems which developed with the commercial time-sharing computers in use. Numerous "system crashes" were experienced during the evaluation iteration of the programs, especially during the first six weeks of the semester. The evaluation may not be generalizable to the use of the same programs with a more reliable, more permanent computer system such as that now aboard at the Naval Academy. In the event of a system "crash" such as the ones which plagued the experimental sections throughout the project, the program run was terminated and the student had to start over at the beginning. Needless to say, this was very discouraging to students, especially midshipmen, whose time was limited. It was also embarrassing and demoralizing to the instructors who assigned these programs to the students.

Instructors faced further system problems derived from the use of a "primary" and a "back-up" system using two separate computer time-sharing services. Because of this, programs had to be loaded onto both systems and files updated constantly so that the two systems were compatible. Also, at one point, a difference in the compilers of the two systems was encountered, causing some programs to run on one system yet not run on the other. These problems caused significant extra expenditure of time on the part of the instructors.

3. DATA COLLECTION RESTRICTIONS

Another serious restriction on the evaluation process was the lack of appropriate measurement instruments such as student study time records, validated student questionnaires, and in some cases, criterion-referenced tests for CAI and control groups. No formal evaluation plan had been devised prior to the teletype evaluation period, so the evaluation design had to simply make the best use of data which were available or could still be gathered. Electrical Science was the only course for which an adequate control group, taught by the same instructors, was available. The control group for Mechanics of Materials was taught by the same instructor, but this was during an earlier semester with a more typical assortment of students for the course.

4. STUDENT BODY CHARACTERISTICS/CONSIDERATIONS

For those interested in making generalizations concerning tutorial-drill types of teletype CAI to other instructional settings, some comments are in order concerning "conventional instruction" at the Naval Academy. As previously noted, the Academy enjoys a very favorable student/faculty ratio. Most classes have an average of twenty students, and few faculty members teach more than four classes. This allows for greater attention to individual students than one normally finds at an institution of higher learning. The midshipmen themselves are highly selected and form a well-motivated and relatively homogeneous, very capable group. Instructional aids such as training films and video tapes, working models, and modern laboratory equipment were widely available. Altogether, the conditions for effective conventional instruction approach optimal levels. Thus, the value of CAI as a supplementary device providing for individualization of instruction through self-pacing and attention to individual differences may well have been reduced in the Naval Academy educational environment. In other situations where the student/faculty ratio is less favorable and the range of student abilities and motivation is greater, tutorial-drill CAI-Teletype may prove to be of much greater value in improving the level of instruction. It is likely that, given a population with greater individual differences, the usefulness of the individual differences approach suggested for assigning students to CAI and non-CAI versions of a course would become even more effective.

F. CURRENT STATUS OF CAI-TELETYPE AT THE NAVAL ACADEMY

In June 1971 a computer usage questionnaire was distributed to all faculty members. Each professor or instructor was asked to indicate, for the courses he taught, (1) those which used remote time-sharing computing as a regular part of the course (CAI as defined in this report) during the 1970-71 academic year; (2) those which would use CAI during the 1971-72 academic year; (3) the form of CAI used; (4) the enrollment; and (5) the number of student hours on-line per semester. Very briefly, the results of this questionnaire showed that:

- Of 540 Naval Academy faculty members, 261 replied to the questionnaire, with 259 indicating that they planned to use CAI in one or more courses.
- Of 570 courses offered by 19 departments, 103 involved CAI in academic year 1970-71. This number is expected to increase to 178 in academic year 1971-72.
- Omitting courses in English, History, and Language Area Studies where CAI is least used, there are 386 courses -- 171 of which will involve the use of CAI in academic year 1971-72.
- Connect time projected for academic year 1971-72 totals approximately 170,900 hours.

Data from computer system utilization reports for October 1971 (the first full month of academic year 1971-72) indicate that faculty estimates were probably low. Of 284 courses offered in the fall term of academic year 1971-72, 83 were estimated to make moderate to heavy utilization of computers (six or more connect hours per student). Utilization data reveals that approximately 92 courses involve substantial computer use and an additional 61 are making casual use of computers. Moreover, with 13,971 connect hours logged in October, it is reasonably safe to assume (since usage increases toward the end of the semester) that the projected figure of 79,504 connect hours will be exceeded.

A breakdown of CAI by users (major departmental groupings) and by techniques is illustrated in Table 1. Figure 8 graphically displays the percentage of use by major department and the percentage of use of the various modes of CAI planned for academic year 1971-72.

G. ANALYSIS OF CAI GROWTH AT THE NAVAL ACADEMY -- FACTORS, TRENDS, AND POSSIBILITIES

The growth of CAI (number of remote terminals, number of courses using CAI, number of connect hours) and the transition from research to operational funding is shown in Figure 9. The increase in faculty members making use of CAI (not shown in figure) has been similarly steep (0 to 1966 to over 260 in 1971). The rates of increase in connect hours and number of courses and professors using CAI show no sign yet of leveling off.

TABLE 1

SUMMARY OF 25 JUNE 1971 COMPUTER USAGE QUESTIONNAIRE RESULTS
TYPE AND QUANTITY OF CAI PLANNED FOR AY 1971-72

Major Dept. Groupings	# Courses Using CAI	# of Students	# Hrs On-Line Per Student	Hours On-Line	TYPE OF CAI (%) Problem Solving	Simulation (Graphics)	Data Reduction	Drill & Analysis	Tutorial (Inquiry)	Testing
Engineering & Weapons										
Fall 71	25	2450	12	29400						
	7	345	6	2070						
Spring 72	38	3540	12	42480	58	24	13	4	-	1
	7	400	6	2400						
Subtotal	77			76350						
Science & Mathematics										
Fall 71	10	1500	12	18000						
	10	1539	6	9234						
Spring 72	5	1000	12	12000	58	28	7	7	-	-
	16	1565	6	9390						
Subtotal	41			48624						
Naval Command & Management										
Fall 71	4	285	12	3420						
	13	500	6	3000	40	25	-	25	-	10
Spring 72	4	285	12	3320						
	6	94	6	564						
Subtotal	27			10304						
U.S. & International Studies										
Fall 71	5	200	5	1000	10	35	-	35	20	-
Spring 72	7	725	6	4350						
Subtotal	12			5350						
History & English										
Spring 72	1	100	5	500	-	20	-	-	80	-
Computer Science										
Fall 71	1	700	15	10500						
	8	240	12	2880						
Spring 72	1	700	15	10500	90	5	-	-	5	-
	5	500	12	6000						
Subtotal	15			29880						
Total	173			170908						

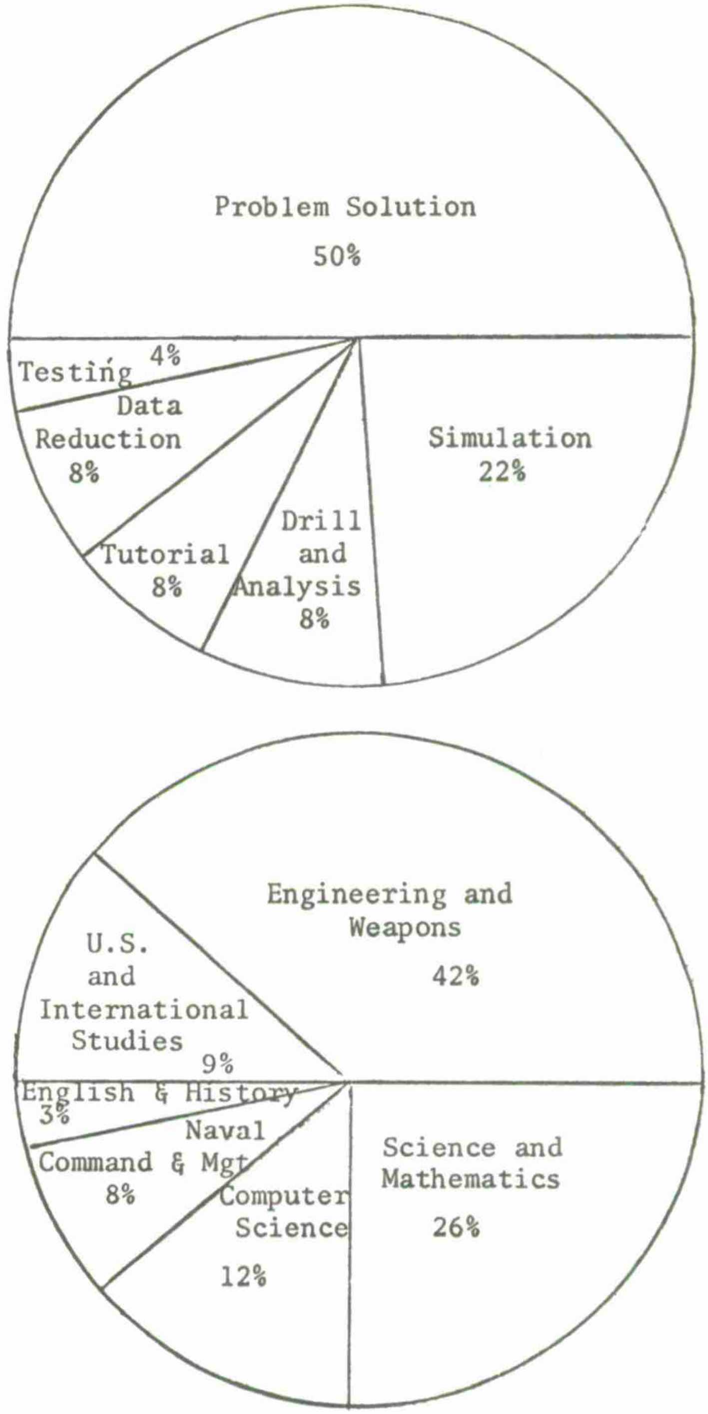


Figure 8. BREAKDOWN OF CAI-TELETYPE UTILIZATION BY USERS AND TECHNIQUES (Fall 1971)

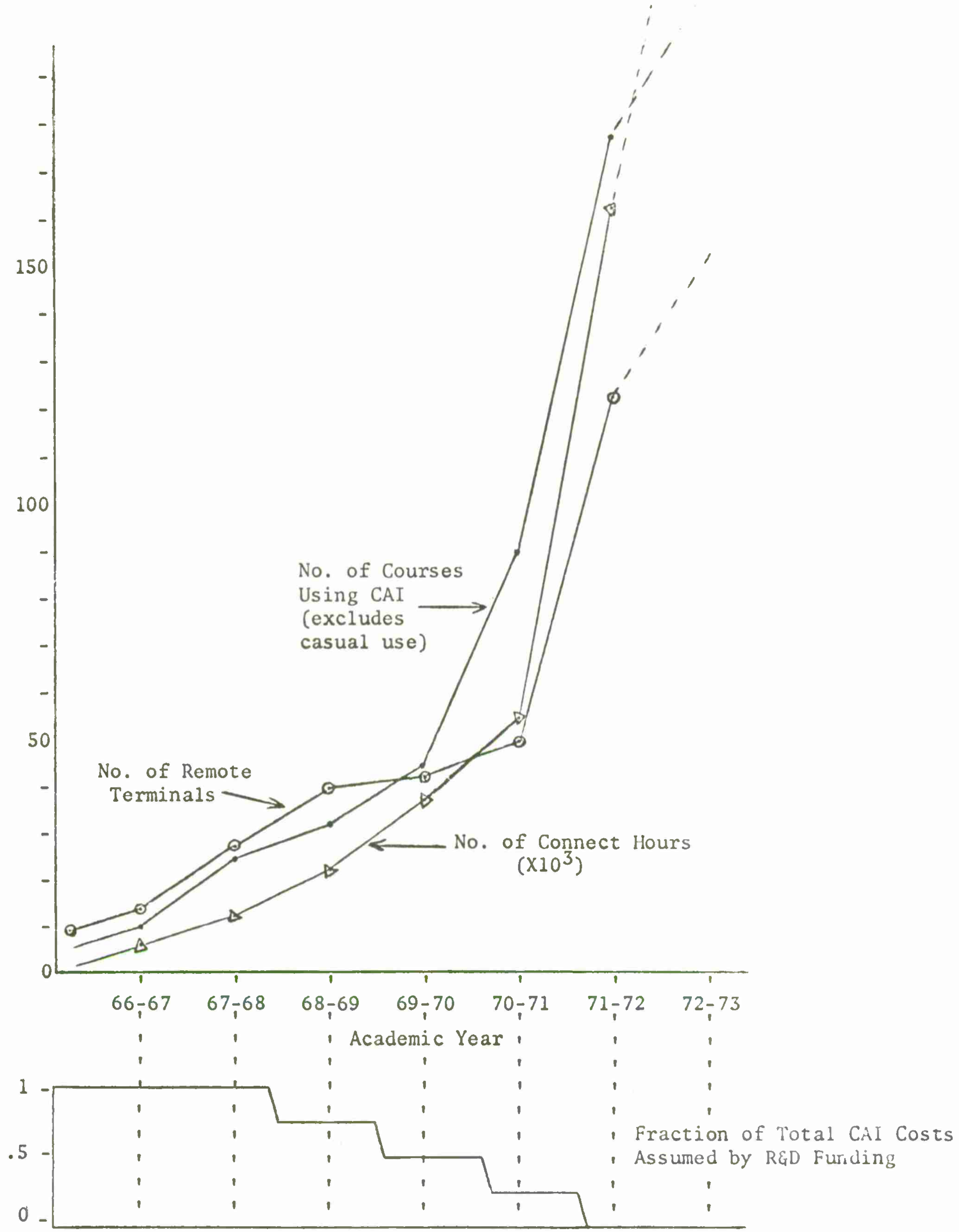


Figure 9. CAI-TELETYPE GROWTH AND TRANSITION FROM R&D TO OPERATIONAL FUNDING
(Excludes: batch processing, CAI-1500 computer utilization
and analog/hybrid computing)

III. THE CAI-1500 PROJECT

A. INTRODUCTION

This chapter describes the development and evaluation of the course materials implemented on the IBM 1500 Instructional System. For a more detailed discussion of the topics of course development and formative, summative, and experimental evaluation, the reader is referred to Supplements F through K (see page ii).

Built around the 1500 system, with a dedicated 1800 processor, this project featured sophisticated remote terminals at which students were presented instructional materials. Each student terminal incorporated two or more of the units depicted in Figure 4 (page 19) under computer control . Management decision for remediation of any desired complexity could be made instantly; thus this system offered full media, management, and self-pacing capabilities. Whereas the focus of the CAI-Teletype Project was on the computer's computational power, the 1500 was utilized in a more extensive, more tutorial manner intended to replace parts or all of conventional instruction in selected situations. Instructional modules (or chapters) for the four academic courses described below were developed for use on the IBM 1500 system:

- General Chemistry -- a two-semester freshman course required of prospective science majors. An Instructional Decision Model, developed during the project for implementing the chemistry CAI material via the computer and for serving as a model for the other courses, should be applicable to similar efforts. Gas Laws, Kinetics, and a semimicro-qualitative simulation were featured in the CAI-1500 materials.

- Modern Physics -- a one-semester elective with considerable emphasis on nuclear power. A modified tutorial approach was used in presenting CAI-1500 materials covering three chapters of the textbook.

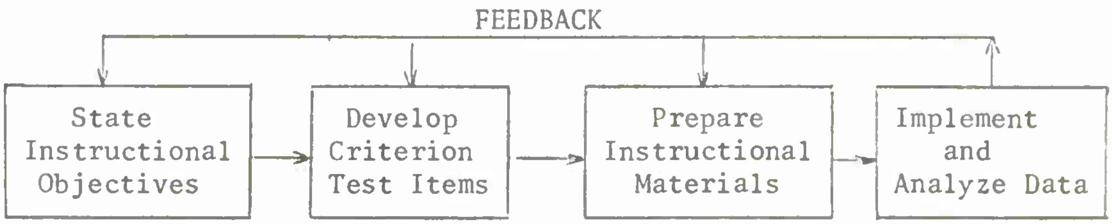
• Naval Operations Analysis -- a four-credit, one-semester elective featuring military applications of advanced probability theory. Eight drill-and-practice modules were developed for the CAI-1500 system, one of which ("Decision Theory") has been reprogrammed for evaluation on the Naval Academy's new Honeywell (GE) 635 computer.

• Basic Russian -- a two-semester introductory course offering six credits. CAI materials for dirll and practice were developed for about one-third of the course. The random-access audio and recording unit controlled by the 1500 system made possible individualized listening and speaking exercises in addition to the reading and writing drills.

B. COURSE DEVELOPMENT

The growing interest and increased use of a variety of self-instructional programs over the past ten years has generated a great deal of discussion about the role of evaluation in assessing the effectiveness of instructional programs presented via programmed instruction (PI), computer-assisted instruction (CAI), and other forms of teaching machines (Holland, 1961; Jacobs, 1961; Glaser, 1963; Hartley, 1963; Cronbach, 1963; Briggs et al, 1964, Lumsdaine, 1965; Glaser, 1965; Jacobs et al, 1966; Gilbert, 1966; Joint Committee, 1966 (a) (b); Tyler, 1967; Scriven, 1967).

The greater array and different types of data generated through the use of self-instructional materials as compared to conventional instruction has been the focal point of the discussions about evaluation. Questions have arisen as to what criteria should be used, how they should be used, and what techniques of analysis should be employed. The developmental model for self-instructional programs has brought about both the increased array of student feedback data and the problems associated with the analysis of that data. Although it can be greatly elaborated upon, the basic model is shown (page 41).



Instructional objectives are stated as descriptions of the expected capabilities of the students after instruction. They are usually stated very specifically as descriptions of a single student capability. Criterion test items are developed in relation to each instructional objective. Student performance is assessed much more frequently in the self-instructional program setting than it is with conventional instruction. After the program is developed and implemented, the information from the analysis of the student data provides feedback to each point in the developmental model. This process of analysis and feedback, called formative evaluation (Scriven, 1967; Stolurow, 1968), is used to improve the program during its development. Formative evaluation is usually oriented towards the parts of the entire program sequence. It provides a diagnostic basis for program revision. Although an overall assessment of an instructional program may show it to be effective, performance on some objectives may be more than acceptable while on others it may be quite unacceptable.

C. PRODUCTION OF CAI-1500 MATERIALS

Production, as used here, encompasses the various processes necessary for converting a course author's specifications and content into smoothly-running CAI-1500 instructional materials. Production, which is a complex and time-consuming process, accounted for the majority of the manpower costs in the Naval Academy CAI-1500 Project and for a substantial amount of computer costs. Thus it is a major management problem and is discussed from that point of view here. More detail, as well as the technical aspects of production, are covered in Supplement C, Production of CAI Materials.

1. AUTHORING

The authors were Naval Academy faculty members. They were selected by their departments to work in the field of CAI primarily on the basis of interest and, to some extent, on the basis of teaching responsibilities and time available. Background in the area of educational design was given little weight in their selection. Consequently a high degree of support from the Technical Support Group of the Educational Systems Center was required. The composition of the Technical Support Group is shown in Figure 1.

Problems encountered in authoring courses revolved around: (1) lack of definition of course content, (2) difficulty in writing acceptable behavioral objectives, and (3) developing criterion test questions. At first some faculty members were not receptive to the procedures proposed by consultants and programmers, but as they gained experience, they recognized the need for specificity in all these areas. Others saw the need and practiced acceptable procedures from the beginning. Many of the problems, however, stemmed from difficulty of communication between authors and programmers.

2. PROGRAMMING

After the instructional material has been developed, it must be entered into the system. Primary responsibility for this aspect of the effort rested with the Technical Support Group. Some course authors, however, became involved with programming, as well as with developing the course specifications; others did not concern themselves with programming at all.

It is difficult to predict what a programming load will be until specifications for a course are written and, on that basis, estimates of programming time developed. Some factors affecting the amount of time required are as follows:

a. Type of Material

If the material lends itself readily to the use of macros (calling of pre-programmed instructions by the use of a single instruction) and if the answer analysis is linear in nature, the material can be programmed rapidly. (See Figure 10a.) However, the answer analysis becomes extremely large (in proportion to the amount of text a student sees) when the course allows the student to take one of several paths, as in Figure 10b.

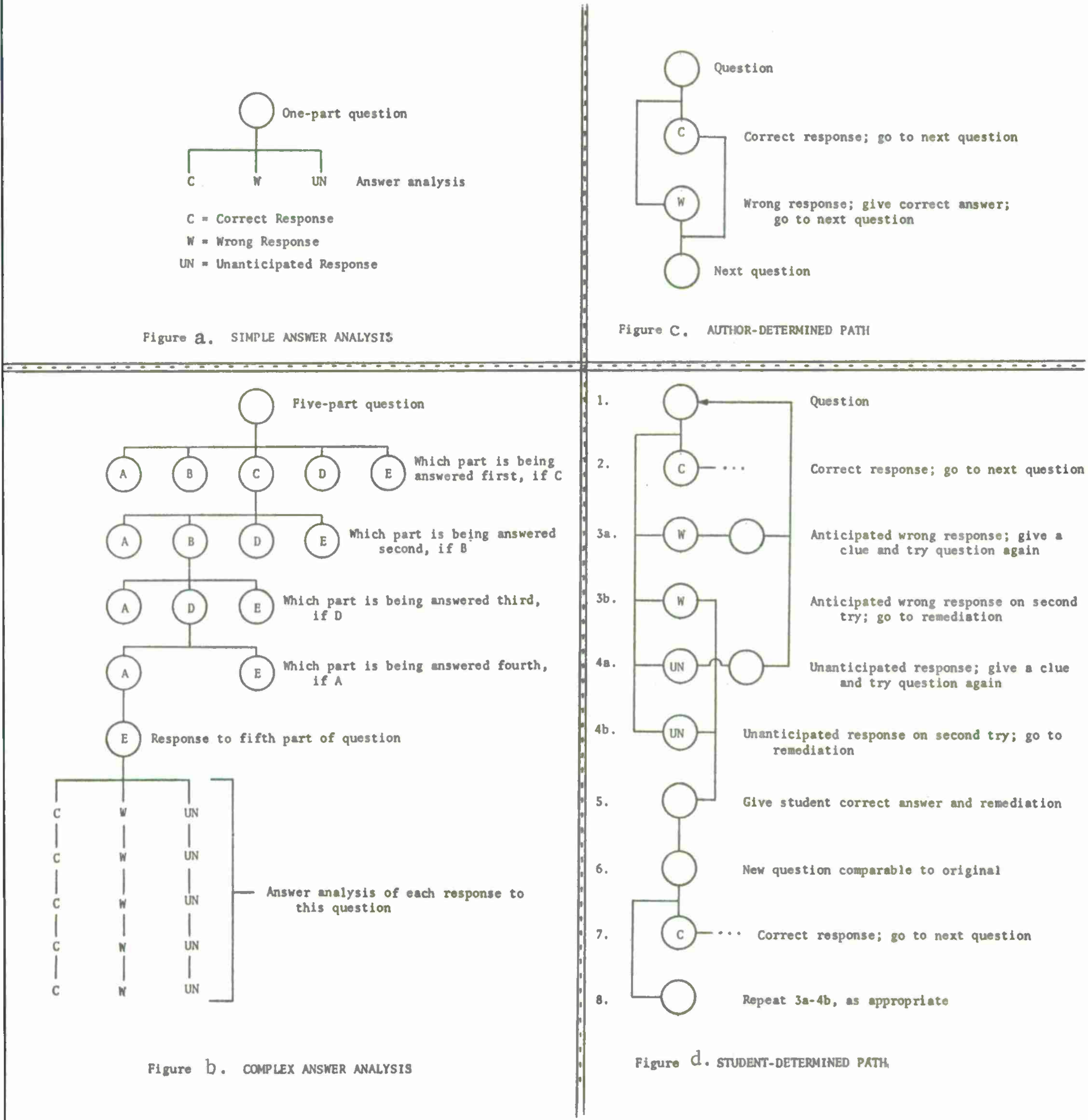


Figure 10. VARIATIONS IN COURSE STRUCTURE

b. Complexity of Course Structure

The course flow may be pre-determined by the author. The author, for example, might specify a simple flow, such as, "Ask the student a question and if he answers correctly, send him on to the next one; if he answers incorrectly, tell him the correct answer and proceed to the next question." (See Figure 10c.) On the other hand, if the author decides to have the student's need determine his path, the routine becomes far more complicated and requires more skill and time in programming. (See Figure 10d.)

c. Volume

The volume of material to be programmed is an important factor in determining the length of time required for programming.

d. Author's Approach

As the author progresses from taking small blocks of material to large portions of a course, the volume of material becomes critical. Under a large-scale system, the students "fan out" over the course material, in accordance with their abilities, motivation, and so on. The larger the course the more rigorous the answer analysis must be to accurately diagnose a student's need.

e. Presentation of Material to Programmer

The manner in which the material is presented to the programmer is an important factor in estimating time requirements. The most efficient way is to present the material on display guides, including labels, enter-and-processing identifier, match response identifiers, and the like.

f. Revisions

This time-consuming aspect of programming is necessary when there are subject-matter changes in the course itself.

3. PRODUCTION SUPPORT

a. Seminars

While the Educational Systems Center was able to provide extensive support to the course authors in the areas of instructional material design and programming, some portions of the development phase required both talents and facilities not available in-house. Recognizing this, the Educational Systems Center arranged for the presentation of informal courses and seminars by outside groups for selected faculty members. Not all faculty-authors availed themselves of the opportunity, with the result that there was an uneven level of author expertise and a great deal of trial-and-error operation during the early stages of production.

b. Film Strips

A purely mechanical support area was the production of film strips for the IBM 1512 image projector which was used in all the CAI-1500 courses. This proved to be one of the major bottlenecks in the program. It required a sophisticated photography process for which the Naval Academy was not equipped. Consequently, facilities outside the Academy had to be used and the time required often slowed progress.

Obtaining artwork from rough sketches or drawings by authors for use on the image projector was originally the responsibility of the Educational Systems Center, but it proved more feasible to have authors work directly with the art studio.

c. Content Review

In addition to mechanical services required during the production of course material, there was also the necessity for content review of the material. Educational Systems Center, in cooperation with the individual faculty members, contacted representatives of the various departments at the Naval Academy as well as qualified personnel from other universities and from projects involved in similar efforts. Project assistance in the areas of programming techniques and documentation standards was also provided by such outside groups as Stanford University's and Florida State University's data management personnel.

d. Consultants

The majority of course material development and implementation was accomplished with Naval Academy talent and facilities. For the needed support in preparing validation and evaluation plans, two outside consultants were obtained: Dr. Edgar M. Haverland, of the Human Resources Research Office, and Dr. Lawrence M. Stolurow (with his associate, Dr. R. L. Brennan) then at Harvard and now at the State University of New York at Stony Brook. In the closing stages of the project, LeRoy C. Rivers, doctoral candidate, Florida State University, served as a consultant regarding statistical evaluations and the final write-ups.

4. COMPUTER LANGUAGE

The IBM 1500 system used the COURSEWRITER II language. The specifications of the instruction set make it essentially a tutorial type language. When other teaching strategies are used it is necessary to work around the language by using functions or employing the instructions in an unorthodox manner. This makes the CAI presentation appear to be a programmed text. What is not seen is the fact that branches are not predicated on a single response but on possibly all of the student's previous responses. Though COURSEWRITER does provide instructions for carrying out this logic, it does not do it in the most efficient manner, e.g., ten COURSEWRITER instructions are used to do what one Boolean instruction would do.

The big limitation in COURSEWRITER was its inability to do floating point and complex arithmetic. It was limited to handling integers up to 32768. Thus the Naval Academy, which is essentially an engineering school, had a CAI system that could not handle the mathematics an engineer uses. Originally, the Mathematics Algorithm Translator (MAT) language was supposed to perform this function, but the limited storage plus other features made it unacceptable. It was replaced by Kenneth Iverson's APL (A Programming Language), but this likewise was not acceptable, primarily because of its incompatibility with COURSEWRITER. That is, the COURSEWRITER and APL languages could not be used at the same time.

The programming staff used imagination in solving many of the problems of COURSEWRITER except for those with a computational aspect.

5. PROGRAMMER-AUTHOR COORDINATION

Authors often submitted materials for programming that were barely legible. Also, they did not always make their intentions clear to programmers, with the result that revisions in programmed materials had to be made. When the author wanted to make revisions, several ways were tried. It was a fairly simple matter if the desired revision meant adding or changing a few instructions. However, if a major revision was necessary, it meant indicating the change on a Display Guide so that the programmer would have an idea of how the author wanted the material to appear on the screen. Two problems could enter here. The listing on which the author had noted his revisions might be misplaced. or the Display Guides might not be with the listing. Thus, the programmer did not realize a major revision was to be made. In addition, after the author had checked the revisions, the programmer or someone else might note that the EP identifiers (which identify each question) were not correct. In the process of correcting the EP identifier, new errors could be put into the program. A solution to all these problems was to standardize the Display Guide as the communication vehicle between the author and the programmer.

There were problems of communication between authors and programmers. Yet, coordinated teamwork between these two groups is essential for efficient production of CAI materials.

A major difficulty in this area was that authors were faculty members drawn from and responsible only to their own departments. The arrangement had several results:

- Programmer personnel tended to be loyal to the author or the course, rather than to the Educational Systems Center. Thus, friction often developed between the programmer and his supervisor as well as other programmers.

- Authors often had other teaching and committee assignments which kept them from putting full time on CAI.
- The Educational Systems Center could not enforce compliance with standards for submitting material in usable form and for the formulation of acceptable behavioral objectives for the course material.

D. MANAGEMENT

1. PLANNING

Planning the number and types of personnel required for the production of CAI course materials is a major management problem. Efficient planning cannot be accomplished unless the types of material to be produced, their complexity, and volume are known. Both authors and computer personnel are involved and they must work as a team.

2. PERSONNEL SELECTION

In general, the manpower requirements will not be the same for the early stage of developing materials and for the operational stage when the materials are used by students. For example, the tasks of system planning and design, logic design, coding, testing, and system shakedown dictate that programming manpower will probably be much higher during the developmental stage than it will be during the operational stage. Conversely, computer operations personnel will not be needed until the computing hardware is installed and will not need to be full strength until the project enters the operational phase.

Essential to both stages, however, is a manager of the group which is responsible for producing the materials and getting them on the system (in this project, called the Technical Support Group). The manager must be able to deal with and evaluate the performance of course material experts and technical personnel as well as schedule and administer the clerical and computing system operations. It is advisable to acquire an experienced person or someone with closely related experience (e.g., a line supervisor at a CAI project).

Systems analysts and programmers made up the Technical Support Group. Here a decision must be made between hiring experienced personnel or trainees. The salaries for experienced analysts and programmers will, of course, be higher, but less training will be necessary. This approach may be especially attractive if the experience has been with the same programming language or system.

The possibility of hiring trainee programmers because of their low salaries may be appealing to management. However, this approach tends to overlook the potential loss in time and cost if the trainee leaves his position.

The best approach seems to be to hire a few experienced technical personnel (programmers and analysts), give them a few weeks to become familiar with the new organization, its mission, the computing system, and programming language, and then hire trainees and/or minor programmers depending on the particular time frame.

3. TRAINING

Training for both authors and programmers is essential, as mentioned earlier in the chapter. A Faculty Course in Educational Technology was provided by the General Learning Corporation, covering such topics as behavioral objectives, criterion tests, and educational applications of the computer.

Shortly before delivery of the system, IBM furnished training personnel and conducted training for three different groups (authors, programmers, and operators) on the IBM 1500 Instructional System.

E. DATA MANAGEMENT SUBSYSTEM

This section summarizes information on the data management subsystem for the CAI-1500 Project. Persons desiring a more detailed description should refer to Supplement B, Data Management Subsystem Report.

1. APPROACH

A data management system must be viewed as a subsystem of the overall instructional system. Therefore, before detailed planning of the data management subsystem (DMS) is undertaken, the total instructional system must be defined precisely, revealing the related subsystems, general information flow patterns, and requirements. A simplified schematic of a general instruction system is shown in Figure 11. This reveals, from a data management perspective, the major elements and information flows in the system. It also illustrates the major functions a computer can perform.

Once the total instructional system has been defined, the following steps must be taken to determine the data management subsystem requirements:

a. Identification of persons who are to receive data; the data they will need and at what level of detail, where, and for what purpose.

b. Analysis of resources available for operation of the DMS, including personnel and the computer system itself.

2. INFORMATION FLOW

The process of developing the learning activities and determining student paths involves many decisions. These decisions are predominantly of two types: (1) decisions made in advance of instruction which are then reexamined on the basis of data and (2) decisions which cannot be made in advance but occur only during instruction. For example, for a given objective, one may prepare three differing sets of remedial information frames corresponding to three states of knowledge that seem likely to exist within a group of students.

During instruction, the state of knowledge for a given student is determined and the corresponding set of frames presented to that student Following instructions one then asks such questions as: Did each remedial set perform as desired, Was each of the three sets necessary, Were the three sets sufficient, Was each student presented the best set of frames for him, How does this method of teaching the objective compare with alternates, What are the cumulative effects of this method, etc.

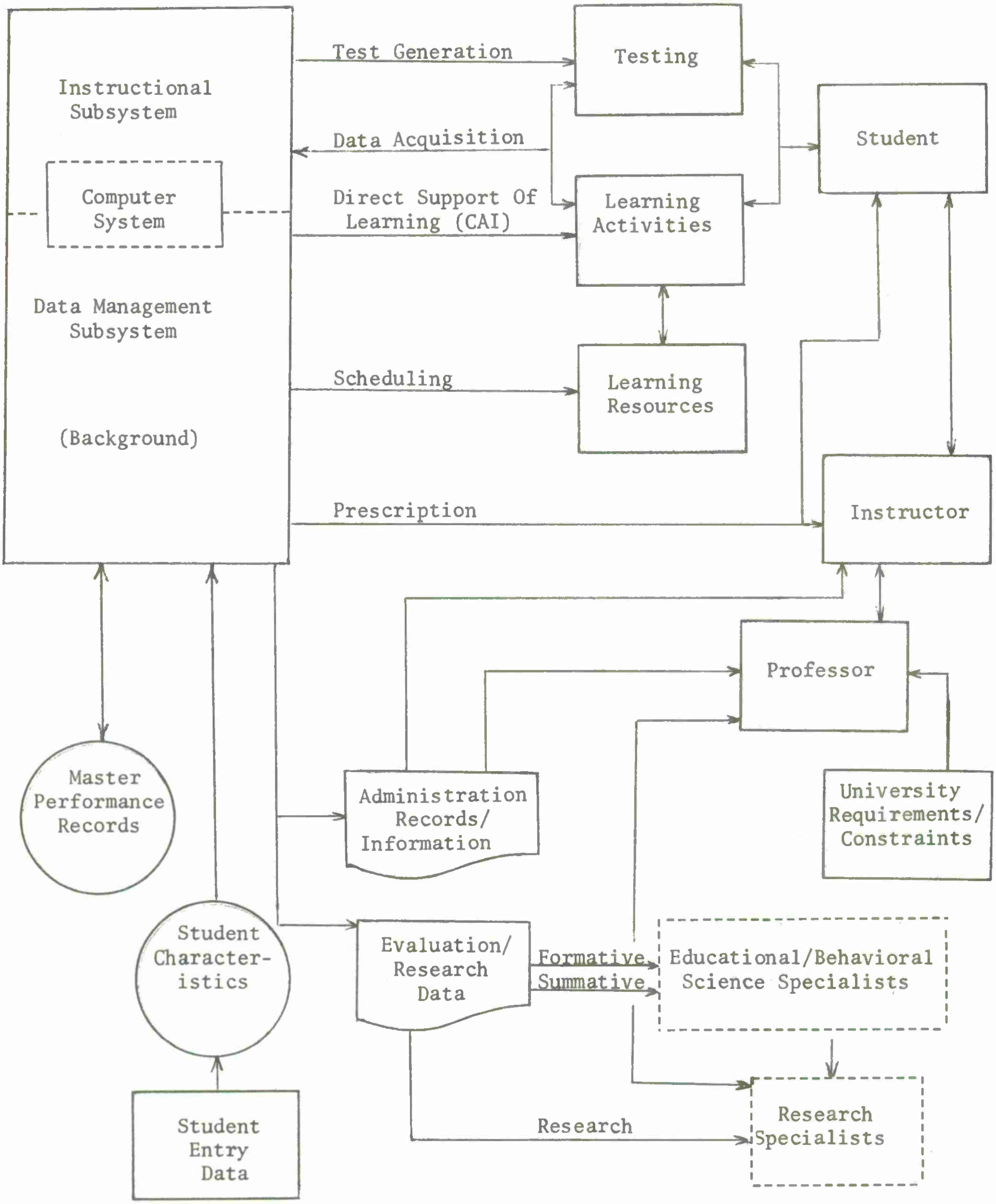


Figure 11. GENERAL INSTRUCTIONAL SYSTEM

The sources of data required for these decisions are student performance data (such as achievement, learning time, latency), student attitude data, instructors attitudes, and student entry characteristics (data about students which is collected prior to the start of the course). For the CAI-1500 Project the bulk of this data was collected on-line, with some attitude data and background data collected off-line and inserted into the system in batch mode.

Inputs to the DMS included student entry and exit data (card input) and raw student performance records (tape input). The items comprising student entry and exit data are listed in Figure 12. The informational flow is shown in Figure 13.

3. RESOURCES

Design of the DMS for the Naval Academy's CAI-1500 Project was an evolutionary process, involving a series of tradeoff decisions based on estimates of the costs and benefits of the many alternatives that arose during the project. Originally, the IBM-1500 system, for reasons of cost and availability, was used for DMS implementation. However, the system had a major limitation for this application: during instructional sessions it was not possible to access any information on magnetic tape. Consequently, no information in student performance files could be retrieved, manipulated, and used as input to instructional algorithms during instruction. This meant that the DMS could not function simultaneously with instruction or directly support instruction in real time. In order to use student performance characteristics data in instructional decision making, the necessary data had to be stored in the "current" student response record. (A limited number of counters and switches are available for data storage in response records.)

The most significant change in the original DMS design came about as a result of the installation of the GE-635 time-sharing computing system at the Academy. Not only does the system have power and speed but it has a capability that proved to be particularly valuable in the CAI-1500 Project data management: the GECOS simulator (a standard batch operating system) allowed background jobs to be processed while the DTSS (provided by

STUDENT ENTRY CHARACTERISTICS

- Student Number
- Aptitude Measures
  - SAT Math
  - SAT Verbal
  - English Composition
  - Math Achievement
- Prior Performance
  - Standard Rank in High School Class
  - High School Recommendations
  - Quality Point Rating
- Personality Measures
  - 16-PF Scores
  - Ohio Psychological Exam Scores
  - Strong Vocational Interest Blank Scores
- Entrance Examination
- Initial Attitude Measures
  - Attitude Toward Subject
  - Attitude Toward Naval Academy
  - Attitude Toward CAI

STUDENT EXIT DATA

- Experimental Group
- Instruction
- Attitudes
  - Toward Subject Matters
  - Toward CAI (Long Exposure)
  - Toward CAI (Short Exposure)
  - Mean Module Usefulness Ratings
  - Number Positive Comments
  - Number Negative Comments
- Attitude Change Toward
  - Subject Matter
  - CAI (Long Exposure)
  - CAI (Short Exposure)
  - CAI (Between Short & Long Exposure)
- Time Measure
  - Total Time Devoted to Course
  - Extra Instruction Time

Figure 12

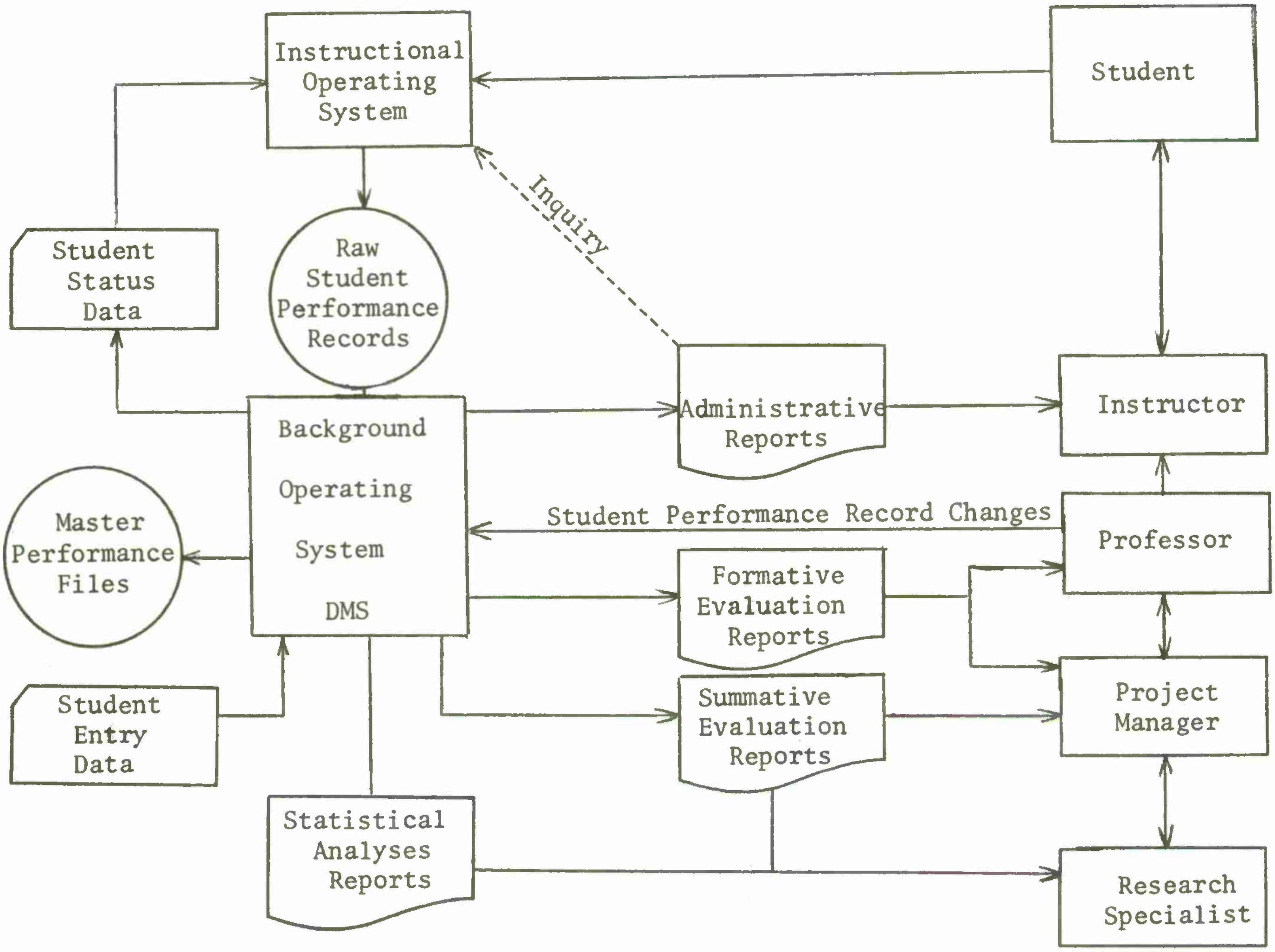


Figure 13. DMS INFORMATION FLOW, REQUIRED OUTPUTS

Dartmouth College for support of time-sharing) was operating. This capability made it possible to debug DMS programs on-line and to execute jobs immediately.

4. FINAL SYSTEM FOR DMS

The final form of the Naval Academy DMS is illustrated in Figure 14. It is composed of two parts. One part operated on the IBM-1500 system and provided administrative and formative evaluation reports. The second part operated on the GE-635 providing the primary information required for research and summative evaluation. Basically, the dividing line between these two parts placed on the 1500 those programs which were run regularly and frequently, while those which were run once or rarely were placed on the GE-635. In addition, the routines which were the more subject to change, required the more sophisticated statistical analysis routines, involved large correlation matrices, and large numbers of types of data were run on the GE-635.

5. STAFF

Many members of the Educational Systems Center (ESC) organization contributed to DMS development. Specifications for administrative, formative and summative evaluation reports were initially provided by the project manager directly to the computer systems manager. Later in the project additional summative evaluation requirements and the research requirements were specified by the research specialist. Change requirements were submitted via the ESC Director but required close coordination between the project manager and computer systems manager.

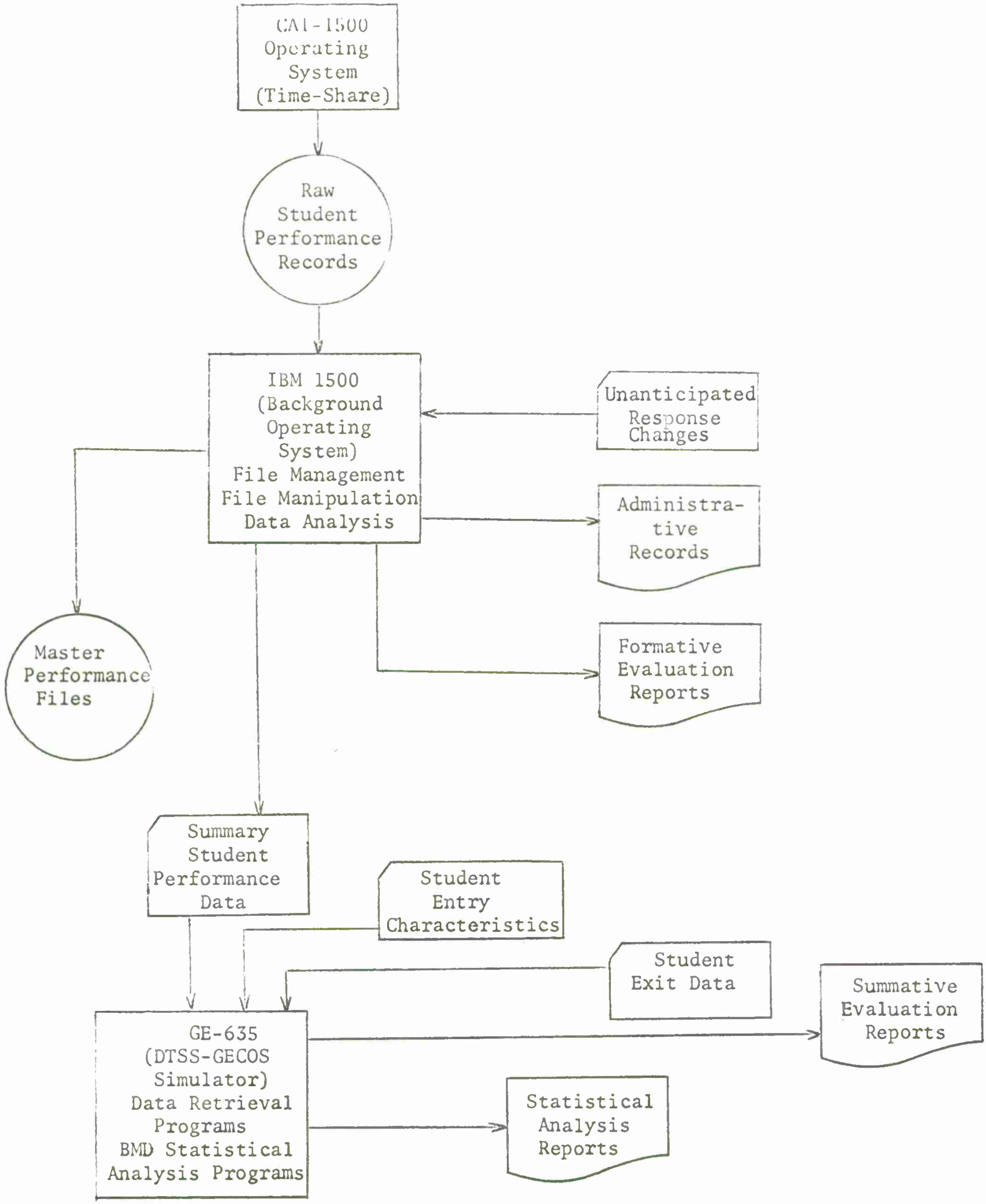


Figure 14. DATA MANAGEMENT SUBSYSTEM

The level of personnel involved and approximate time expended in DMS development was as follows:

Project manager	GS-13		1/4 man years
Research specialist	Associate Professor		1/8 man years
Computer systems manager	GS-13	1/2 time	1.5 man years
Applications programming manager	GS-9-11	full time	3 man years
Applications programmer	GS-7-9	1/4 time	3/4 man years
Operators	GS-4-5	1/4 time	3/4 man years

The relative amount of effort required for development of the IBM-1500 and the GE-635 portions of the DMS was approximately 20 to 1.

6. PROBLEM AREAS

A number of problem areas contributed to high costs in developing the DMS. Among these were: management of a complex staff; differences among the four courses for which CAI materials were developed; changes in instructional models; emergent ideas about formative evaluation requirements; methods for establishing identifier fields (the key to all select and sort routines); the use of counters and switches in student response records; inquiry capability permitting students and instructors to obtain performance data on-line; availability of languages and utility programs; and procedures for achieving a routine process.

F. IMPLEMENTATION

1. TRYING OUT MATERIALS

The lack of available students to try out materials proved to be a problem. One might expect that midshipmen could be brought to a classroom for this purpose at any time of day or night. However, as previously stated, the midshipman's time is very precious and is well accounted for. It was thought originally that some students might be available during the summer, but even then time is scheduled for summer cruises and the like.

As a result, the Educational System Center had to rely on the opinions of non-authoring faculty members as to how successful the materials might be in teaching students. Thus, a regular class was the first group of students to see the materials.

2. INTRODUCING STUDENTS TO THE SYSTEM

Several methods of introducing students to the system were tried. Initially they were told something about what was available and then taken through a series of exercises in which they learned to "enter" their answers. Later, they were simply told what to do and then put on the system. More recently, the procedure was to give them about fifteen minutes of exercises and then start them into regular course materials.

3. PROCTORING

When authors participate in the proctoring function, students are tempted to ask them for help which is not really necessary. It is difficult for the authors to refrain from helping the students as they want them to get through the materials with the minimum amount of interference from mechanical difficulties with the system, whether hardware or software related. In the initial presentations it was necessary for the author to be a proctor so that he could observe how the students were reacting and could help those who got into trouble because of programming or system errors.

Eventually it became easier to determine the type of trouble a student was having and for the non-author proctor to rectify routine problems. Authors were encouraged to remain in the room adjacent to the classroom. Since this gave the authors a chance to analyze data and do other tasks, they were happy to comply.

4. SCHEDULE

As can be noted in Table 2, the development of the CAI materials for the four courses was begun at various times throughout the project. When time permitted, the course materials were subjected to review by one or more students in order to eliminate obvious errors and inconsistencies in the CAI programs. However, in most cases, the course materials were completed barely in time for the start of classes, and the initial implementations of materials developed in 1967 were plagued with many problems. The Physics course was the most problem-prone, while the Naval Operations and Russian materials proceeded with relatively few problems. The development of all the courses was hindered in some respect by curriculum and personnel changes.

Each course represented a slightly different mode of CAI presentation, from drill and practice to some form of tutorial. In addition, different strategies were employed in their development. Over the history of the project, the strategies employed changed within some courses. In the Chemistry course, for example, the CAI materials were initially intended to provide drill and practice on solving various quantitative aspects. However, in the summer of 1969 the materials were reduced in terms of the number of topics covered and the remaining topics were expanded to a more complete tutorial format.

TABLE 2

DEVELOPMENT, IMPLEMENTATION, AND REVISION TIME FRAMES
FOR THE FOUR CAI COURSES*

Course	Initially Developed	Implementation	Revisions
Chemistry			
1st Semester Materials	Summer 1967	Fall 1967	Spring and Summer 1968
		Fall 1968	Spring and Summer 1969
		Fall 1969	Spring and Summer 1970
		Fall 1970	
2nd Semester Materials	Spring and Summer 1969	Spring 1970	Summer 1970
		Spring 1971	
Physics	Summer 1967	Fall 1967	Continuous efforts at revision and implementation from Spring 1968 to Fall 1969
		Spring 1970	Summer and Fall 1970
		Spring 1971	
Naval Operations	Summer 1968	Fall 1968	
		Spring 1969	Summer 1969
		Fall 1969	
		Spring 1970	Summer 1970
		Fall 1970	
		Spring 1971	
Russian			
1st Semester Materials	Summer 1968	Fall 1968	Spring and Summer 1969
		Fall 1969	Spring and Summer 1970
		Fall 1970	
2nd Semester Materials	Spring and Summer 1969	Spring 1970	Summer 1970
		Spring 1971	

*See Supplements H-K for a complete description of the development of the four courses.

G. REVISION PROCEDURES

Since the courses being developed were part of a first effort in a new area, revision was inevitable. The amount of revision necessary varied with the course and, to a great extent, depended on the period of course development. That is, the earlier the course was developed, the greater likelihood that revisions would be needed. (For more detail see Supplement F (Formative Evaluation of the CAI-1500 Project Materials).

Generally speaking, the revisions were taken care of during the early months of writing and programming. Revision was required, however, throughout the life of the project as a result of other developments. Among these were curriculum changes, staff changes, review of materials by persons other than the authors, and difficulties revealed by an analysis of student data during the try-out phase. For example, a student might enter what was a correct answer to him, only to have the computer reject the answer and provide him with unnecessary remedial material. (Regardless of the care exercised in the development of instructional materials, a certain amount of this type of revision appears unavoidable.)

Some of the revisions were hardware/software dependent and therefore affected all courses. Among these were such things as (1) the amount of text that should be displayed on the CRT at one time, considering its readability; (2) the complications, manpower, and time involved in preparing illustrations for use on the image projector, as mentioned earlier, and the feasibility of using graphics on the CRT when considering cost in time and machine efficiency versus the educational value of the graphics. The original courses underwent fairly extensive changes to help overcome these problems.

A report was compiled by the Educational Systems Center* regarding the evaluation of the CAI-1500 course materials as they

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*Summary Validation Report on the CAI-1500 Courses Developed at the U. S. Naval Academy, No. PR-1070-35R, Educational Systems Center, U. S. Naval Academy, Annapolis, February 1971.

were implemented in the academic year 1969-70. Revisions of some form were made to all of the course materials during the summer of 1970, and all the courses were implemented at least once during the 1970-71 academic year. Although formative evaluation data on course performance during this year was tabulated, no further revisions were made.

The formative evaluation process involved careful examination of all performance objectives; the validity, reliability, objective-relatedness, and comparability of test items; and the quality, quantity, and organization of content, and its pertinence to the defined objectives. This required scrutiny of curriculum specifications, the conventional course prospectus, the test, the CAI objectives and programs, student performance data, and student attitude indexes.

First, CAI-related objectives, which had been generated by course authors and approved by their parent academic department, were reviewed to assess whether they were (1) sufficiently inclusive of the depth and scope of the learning sought in the course; and (2) adequately specific as to the type of behavior, the degree of mastery, and the conditions for its demonstration, all of which are considered essential to formulate fair and relevant criterion instruments and to enable optimal selection and use of strategies, media, and content. Those individuals designated as course evaluators examined the objectives defined in relation to the course syllabus, the CAI content and questions, and in some cases, the text.

Course evaluators next studied CAI test items. They reviewed all program questions, most of which had reportedly been drawn from department pools of previously validated questions, for (1) their relevance to objectives and to the instructional materials; (2) their apparent comparability in difficulty; (3) their consonance with the rules for sound question construction; and (4) student performance thereon. The questions pertinent to each objective were evaluated separately.

Expectedly, the types of questions in widest use were found to be constructed response, true/false, and especially, multiple-choice. They were further categorized according to their utilization within programs. The pre-test item intends to determine the level of student proficiency prior to instruction in order to teach to his needs. The diagnostic question discerns the nature of a student's problem so that he may then be branched to remediation tailored to meet that inadequacy. The check-test provides drill or self-testing and is properly as difficult as the pre-test and post-test questions since it should reveal to the student whether he has mastered the objective. Finally, the post-test item measures ultimate achievement of the terminal objective-related behavior.

Instructional content was then inspected for its relevance to the behavioral objectives, sufficiency for achieving the desired level of learning, and its application of accepted principles of clarity, vividness, logic, difficulty, etc. Particular attention was given to the remedial sequences which were aimed at specific student misunderstandings.

The analysis of student performance data was especially revealing in those courses which had been structured to allow measurement of individu student gain between pre-test and post-test performance. It was expected that synthesis of individual performance data would pattern out the major program weaknesses, and further, would disclose the effectiveness of materials and activities such as review.

H. EVALUATION RESULTS

Results from the present evaluation of the CAI materials that have been prepared and used at the Naval Academy lead to several hypotheses concerning CAI and the state of the art of CAI. It is extremely important, however, that the reader remind himself that the present evaluation is in reality a case-study and that the results and patterns of results which emerged may be limited in their generality. These findings simply show what resulted when CAI was employed as it was at the Naval Academy. Definitive statements of what will always or even usually happen when CAI is used can be made only when results of other CAI projects are assessed and compared with those of the present evaluation. For a more detailed description of the evaluation of the CAI-1500 materials, see Supplement G (CAI-1500 Project Evaluation Report).

1. TIME SPENT ON-LINE

It should be noted that the fall Chemistry CAI materials were tutorial in nature and they totally replaced two weeks of classroom instruction for the semester. The spring Chemistry materials were of the drill-and-practice mode, and they were used in lieu of conventional homework on the topic of Kinetics. Students spent a range of 4.2 to 14.9 hours on-line with the fall Chemistry CAI materials and from .8 to 1.9 hours on the spring Chemistry CAI materials. The Naval Operations Analysis CAI materials, like those of spring Chemistry, were drill-and-practice in nature, and one two-hour class session every two weeks was allotted for practice on these homework problems. Students spent a range of 3.5 to 10.7 hours on-line with the NavOps CAI materials. The Russian CAI materials were also of the drill-and-practice mode, and they replaced one 50-minute class session a week. Students spent a range of 5.8 to 23.8 hours on-line with the Russian CAI materials.

2. EXAMINATION PERFORMANCE

Control groups receiving conventional instruction were available for comparison with the CAI students in each course except Physics. Statistical comparisons were made on a variety of combinations of hour exams and final examinations as well as total time spent.

Most test items were related to objectives covered by the CAI materials (dual treatment items). The score on these items were designated as the CAI-related score to indicate that these were scores on which a direct comparison could be made between the CAI treatment group and the conventionally taught treatment group. The other test items (common treatment items) were scored and made up the non-CAI-related score. This score reflected performance on conventionally taught materials for both treatment groups. Table 3 indicates the number of students in the CAI and conventional treatment groups for each course, and presents comparative percent performance on all examinations. There was one course where the performance of a CAI group was significantly more favorable than that of the corresponding control group. In the analysis of the data from the Russian course, the performance of the CAI students on three of the exams was statistically significantly better than that of the control students recieving conventional instruction. (Table 3.)

3. TIME COMPARISONS

While there were no overall time savings through the use of CAI for the students as a group, the instructors were enthusiastic about the time savings to them particularly in the problem solving and homework aspects of their course. They appreciated that more time could be spent on the theoretical aspects of their instruction.

TABLE 3

EXAMINATION PERFORMANCE BY TREATMENT GROUP FOR THE FOUR CAI-1500 COURSES

	Treatment Group	
	CAI	Conventional
FALL CHEMISTRY - Number of Students	43	49
Hour Exam - CAI related score	75[a]	72[a]
Hour Exam - Non-CAI related score	56	60
Final Exam - CAI related score	75	77
Final Exam - Non-CAI related score	56	57
SPRING CHEMISTRY - Number of Students	49	49
Hour Exam - CAI related score	73	74
Hour Exam - Non-CAI related score	58	60
NAVAL OPERATIONS ANALYSIS		
FALL SEMESTER - Number of Students	34	32
Final Exam - CAI related score	75	72
Final Exam - Non-CAI related score	65	65
SPRING SEMESTER - Number of Students	61	62
Final Exam - CAI related score	59	57
Final Exam - Non-CAI related score	45	46
FALL RUSSIAN - Number of Students	9	13
Hour Exams Total Score	66	69
Pre-Final - CAI related score	55[b]	45[b]
Pre-Final - Non-CAI related score	67	69
Final Exam Total Score	66	60
SPRING RUSSIAN - Number of Students	9	8
Hour Exams Total - CAI related score	88[c]	67[c]
Hour Exams Total - Non-CAI related score	80	82
Pre-Final - CAI related score	39	39
Pre-Final - Non-CAI related score	60	80
Final Exam Reading Score	40	39
Final Exam Listening Score	44[c]	38[c]

[a] All exams scores are given as percentages.
[b] Statistically significant difference: $p<.10$.
[c] Statistically significant difference: $p<.05$.

NOTE: NavOps materials used were the same in fall and spring. Chemistry and Russian (both being two-semester courses) used different materials in fall and spring.

4. STUDENT ATTITUDES

a. Subject Matter

In the two cases where attitudes toward subject matter were assessed (NavOps and Russian), it was indicated that the use of CAI may favorably influence the attitudes of students who do not already have relatively favorable attitudes while it may have a neutral or slightly adverse effect on attitudes of students with very positive initial attitudes. The results indicate the need for a control group in assessing changes in attitudes toward the subject matter. In both Russian and NavOps, student attitudes toward the subject declined significantly over the semester. However, the much lesser decline experienced by the CAI students might be considered an improvement in student attitude.

b. CAI

Attitudes toward CAI itself were significantly more positive for CAI students, than control students in all cases except those for spring Russian. An interesting finding relative to attitudes toward CAI was that the CAI students invariably showed more positive attitudes toward CAI than the control students before either group had been on-line. While control group attitudes remained relatively constant across the course, the initial experience on-line caused CAI student attitudes to become even more favorable. This increase was temporary for the fall and spring Chemistry CAI students since their attitudes returned to their initial (but positive) level after CAI was discontinued. The fall and spring CAI NavOps students maintained favorable attitudes. A definite decrease in favorability occurred for Russian CAI during the end of the fall semester and all of the spring semester. The Russian materials were more time-consuming and assessed to be somewhat more difficult for the students than the other course materials. This suggests that the student's attitude toward CAI materials may reflect the difficulty the student has with the materials more than the degree to which they benefit him on exams.

5. INSTRUCTIONAL DECISION MODELS

It should be recognized that the CAI instructional materials used in this evaluation went through several revision cycles. However, due to "re-starts" necessitated by curriculum changes, they are not necessarily considered perfect teaching packages. It is felt that instructional outcomes could be improved with further revision cycles.

In the same respect, with insights gained from previous iterations, the instructional decision models could also be improved. The instructional decision models employed with the Naval Academy CAI materials were generally unsophisticated and not at all similar to the Utopian models vaguely outlined by enthusiastic proponents of CAI. They were, instead, simplistic models employing "obvious" principles (such as "do not teach the student what he already knows"). However, sophisticated models which have been empirically proven were not and are not presently available.

The decision model used with fall Chemistry was appropriate for a majority of the students, but it allowed a sizable group of students who performed well on pre-tests to bypass instructional materials which, judging from post-test performance of these students, were sorely needed.

The model employed with the Russian materials, while effective in terms of facilitating examination performance, led to a great deal of repetition and error making for even the brighter students. Thus a distaste for the materials developed, as evidenced by questionnaire responses and time spent on-line. This aversion for the CAI materials would not be expected to be conducive to educational advancement. None of the decision models incorporated off-line data into instructional decision making and none of the models adequately pointed students toward off-line assistance when it became apparent that on-line materials were not producing effective results. The individual differences analyses indicated that personality and attitudinal scores as well as ability test data should be consulted in making instructional decisions and assignments if the full value of the tutorial and drill-and-practice modes of CAI is to be demonstrated.

6. CAI TECHNIQUE AND INDIVIDUAL DIFFERENCES

Two techniques using the CAI-1500 system were adequately tested: (1) the total-tutorial mode, wherein all necessary instruction is given on-line, and (2) the drill-and-practice mode, wherein basic instruction occurs in class while skills are strengthened through use of CAI. A third mode, adjunctive-tutorial, embodied in the Physics CAI materials, but class enrollment limitations precluded their assessment in conjunction with a control group.

The problem-solving drill application of CAI as used with NavOps, Russian, and spring Chemistry appear to be most beneficial to students who would be expected to do well in these courses. It can be hypothesized that the drills and reviews benefit these students mainly because the students are more likely to have whatever minimal grasp of the material is necessary to benefit from drills and review. Such students can discover the weak points in their knowledge through CAI and then correct their weaknesses using only the brief hints provided on-line or their own resources. Students who lack a minimal grasp of the material to be drilled on-line received relatively little assistance on-line and thus cannot benefit much from the CAI materials. It would appear that more extensive remediation should be provided for these students.

The sole case of total-tutorial CAI, fall Chemistry, seems to be most successful, relative to conventional instruction, with students who would be expected to experience difficulty in learning the materials. Since the CAI instruction is "self-contained" and requires fewer entry skills, no one is "lost" at the start. As previously mentioned, the fall Chemistry deicsion model was not as effective with all students scoring well on the pre-tests as it was with students doing poorly on pre-tests.

The greatest advantages expected from CAI in general are due to hypothesized individualization of instruction. CAI would ideally tailor the instruction to fit each student on the basis of his abilities, personality, and prior knowledge and present performance. The conditions of conventional instruction at the Naval Academy probably are conducive to "individualizing" instruction already. Classes are small (20 or fewer students) and the range of abilities and background is relatively small within each class due to admission and placement procedures at the Academy. Thus the instructor can pitch his presentations, text, and reading assignments to a level not too far above or below that of all students in his class. Since the instruction situation at the Naval Academy allows for individualization to this extent, it appears that if CAI materials are to be significantly more effective than conventional instruction in this setting, they must employ teaching conditions and principles superior to those in general use at the Academy. At the present time these principles do not appear to be adequately and reliably established.

IV. FINDINGS AND CONCLUSIONS

A. RELATIVE TO MAJOR GOALS

The major project goals, as stated in Chapter I, were to evaluate the use of the computer as a tool in performing certain instructional functions, specifically:

1. INDIVIDUALIZING INSTRUCTION

a. CAI enabled students to go through the materials at their own rate. In Russian, for example, some students completed the instructional material in six hours; some took 24 hours to go through the same material.

b. CAI enabled instructors to identify individual differences among students and to provide remediation for those who needed it. (However, as was noted, the Naval Academy does not provide the same wide range of individual differences as would be found in most civilian institutions of higher learning.)

2. FACILITATING SOLUTION OF COMPLEX PROBLEMS

The teletype gained great acceptance by both faculty and students because of its effective utilization in solving design and engineering problems. It was particularly effective in such courses as Underwater Acoustics, Fluid Mechanics, and Physics.

3. DETERMINING OPTIMUM COURSE CONTENT

a. The development of CAI course materials required instructors to be precise in stating behavioral objectives and, consequently, to re-evaluate course content. This was particularly true in Chemistry.

b. Some courses changed due to changing curriculum requirements which should be expected in any college environment. This caused problems in CAI material revision and data.

4. RECORDING AND ANALYZING STUDENT PERFORMANCE DATA

a. The computer aided the instructors in readily obtaining the data which indicated where students were having difficulty in mastering material and where course revision was necessary.

b. The methods for recording and analyzing data as well as for producing the materials and managing the program had to be developed. CAI theory and practice was at a primitive stage when this project started.

B. RELATIVE TO STUDENT ACHIEVEMENT, ATTITUDES, AND TIME

1. Teletype use increased the amount of subject matter covered in the courses. It particularly relieved students of the burden of large and complex manual calculations and provided more time to understand principles.

2. Computer use in the tutorial mode to supplement conventional instruction was more in the direction of increased course depth and quality than increased coverage, decreased cost, or relief from teaching "less appealing" parts of the course.

3. Teletype use was more successful in topics of greater difficulty and those requiring creative/intuitive thinking than in those involving rote-learning.

4. The teletype was an extremely powerful teaching tool in simulations, solutions of complex problems, laboratory data reduction and analysis. Eight courses were soon using these techniques operationally. It was less successful when using drill and practice and tutorial techniques. Three courses using these techniques did not go operational but were continued as research projects. Improved student achievement was not demonstrated using these techniques.

5. In the 1500 Project, there were no significant differences between the performance of the CAI groups and the control groups except in the

Russian course where the CAI group showed significantly better achievement than the control group.

6. In the 1500 Project, there were no overall time savings through the use of CAI for the students; however, the instructors were relieved of many of the problem solving and homework aspects of the course and could devote this time to other instructional duties.

7. Student attitude toward the tutorial type of CAI techniques was generally favorable, reaching a peak near mid-semester. Their evaluation on whether or not the CAI support had helped them was generally positive.

8. The more closely the student was connected to the computer and personally participated in the programming, (as in the CAI-Teletype Project), the better his understanding of the subject matter.

C. RELATIVE TO CAI TECHNIQUES

1. The non-computational techniques (drill and practice, tutorial, testing) did not result in the same degree of acceptance and enthusiasm by the faculty and students as did the computational techniques (problem-solving, simulation, data-reduction and formatting). These techniques cannot be compared directly on the basis of student achievement or time/cost savings.

2. Techniques which permitted the faculty and student to interact directly with the computer and participate by writing or changing the program (CAI-Teletype) were more widely accepted and used than techniques requiring a technical staff to do the programming (CAI-1500). Approximately 50% of planned academic year 1971-72 connect time will involve the use of problem solving, and over 20% will involve simulation techniques. Again, these two techniques cannot be compared directly on a basis of student achievement or time/cost savings.

D. RELATIVE TO UTILIZATION

1. Use of the teletype significantly increased student participation in the subject matter of the courses.

2. The use of teletype expanded very rapidly with additional faculty and midshipmen learning to write programs. The number of leased terminals installed doubled each year for three years. Use was limited by operational funds available for vendor service until the installation of a large time-sharing system (GE-635).

3. Growth of teletype use was Academy-wide rather than by academic discipline.

4. The 1500 system was not configured so that faculty and students could easily use it.

E. RELATIVE TO COMPUTER HARDWARE/SOFTWARE

1. The original enthusiasm shown by faculty and students diminished during the early stages; and expanded use of the system was in question for a time until both the teletype and 1500 systems were made highly reliable.

2. The 1500 system's capability to randomly access large video and audio files and to record data made it an excellent instructional research tool. Where configured for this type of work, however, its capacity to handle the many other educational computer needs, such as computational work, was severely limited.

3. The 1500 system was limited in its use to support a large student load due to the maximum of 32 terminals that can be used simultaneously.

4. The GE-635 proved to be exceptionally capable in handling the computational aspects of CAI (problem solving, simulation, and data reduction and formatting).

5. Computer language for the 1500 (COURSEWRITER II) is essentially a tutorial type language. This language had severe limitations in numerical calculations, string-processing capabilities, and in flexibility of programming. A great deal of effort was expended in training personnel and in using this language throughout the project.

F. RELATIVE TO STAFF AND SUPPORT REQUIREMENTS

1. The management of the support staff needed to properly prepare the educational material for use and to collect and analyze test data consisted of a diverse group of experts and technicians, whose coordination resulted in a highly complex operation.

2. The collection, management, and analysis of the test data relative to the amount of course material prepared required resources far in excess of what was originally anticipated.

3. Preparation of satisfactory material for CAI use required the author to have experience in using and improving his material repeatedly during its use in the CAI mode.

4. One of the most severe problems in producing and revising material for the CAI-1500 Project was the fact that most authors could not work directly with the computer. The programmer interface was an ever-present communications barrier unless the author either used clear, detailed Display Guides or learned the specialized COURSEWRITER II computer language.

5. Careful planning and timely production of teaching aids -- such as art work, film strips, and audio tapes to support the course material -- is absolutely necessary to the project.

6. Faculty changes due to rotation and loss affected the orderly execution of this project due to its long term nature.

G. RELATIVE TO COST

1. Use of the teletype for computational CAI techniques provides an estimated reduction in the order of 5-to-10-fold for solving problems and analyzing laboratory data as compared with "conventional methods." Cost of vended time shared service ranges from $4 to $6 per terminal hour, depending upon capability and degree of reliability of both the remote computer and communications. Cost may be as low as $2 to $3 per terminal hour for an installed time-sharing system. A student in one course making moderate to heavy use of computers (12 hours per semester) would therefore cost from $24 to $72 per semester. Such cost can be justified and considered cost-effective based on increased course level -- the incorporation of advanced concepts, techniques, and complex problems.

2. The use of a dedicated system similar to the IBM 1500 for non-computational CAI techniques is extremely expensive; and with the present state-of-the-art of CAI, it is evident that there are many alternate ways of providing the same teaching effectiveness at lower operational cost such as special programmed instruction texts.

3. Factors contributing to both CAI-1500 and Teletype Project costs, when the maximum staff was employed (1970-71):

	Average Cost Per Year
Hardware (IBM 1500 System)	$ 183,000
Vended Time-Sharing Service (Teletype)	60,000
Management Staff	81,000
Programming Staff	104,000
Consultants	30,000
Miscellaneous (travel/supplies)	20,000
Faculty (no summer hire during this period -- during 1968-69 was $30-40,000 per year)	--
Total Average Cost (1970-71)	$ 478,000

4. Development time for the CAI-1500 courses varied widely and required considerable effort to revise. The development time per student instruction hour using the IBM 1500 system appears so high that, unless it could be used for a large number of students for a long period of time, it would not be operationally cost-effective. The table below includes man-hours for authoring, programming, and computer operator support.

	Initial Development	Revision	Total	Development Time Per Hour Instruction
Naval Operations	2483	2543	5026	325
Russian	3675	2894	6569	183
Chemistry	Data Not Available		3810	317
Physics	Data Not Available		2545	424

5. The instructional material development costs can be reduced by imposing the following controls:

a. The instructional model should be fixed at an early stage.

b. Inputs by behavioral and educational technologist must be entered at a specific and optimized point (and as early as possible).

c. Research and evaluation design features must be realistic and specific at the start.

V. RECOMMENDATIONS

The following recommendations are addressed to those educational institutions (military or civilian) that may be contemplating CAI applications in their instructional programs. If an institution decides to become involved with the use of CAI, the following recommendations, based on the Naval Academy's experience and the present state of the art, may be helpful in minimizing time and cost while maximizing effectiveness.

1. Use of the CAI-1500 system for non-computational techniques (tutorial, drill and practice, testing) was not operationally or financially effective at the Naval Academy. It is recommended that, if a dedicated system is to be used operationally for instruction, the following conditions should exist:

- Reliable computer system is mandatory.
- Large numbers of students are necessary to reduce cost per student.
- Programs should be simple to write and easy to change.
- Instructional material should remain reasonably static so that frequent changes are not required.
- Considerable effort must be devoted to planning the production of the CAI materials and the data management subsystem.
- The system must be capable, not only of providing instruction, but of managing data on student performance.
- The institution must have personnel resources available to provide qualified support in many areas, such as psychology, educational technology, and computer programming.

2. From a cost-effective viewpoint, a dedicated CAI-1500 type of system is not recommended in a university environment for operational use. More hardware/software system development is required to reduce cost; and a great deal of educational technology research must be done to improve development of instructional materials as well as the management of student learning. The few courses involved and the relatively small portion of each course committed to CAI in the Naval Academy 1500 Project emphasized both the complexity of using these techniques and the dearth of existing knowledge on how they can be used successfully in a college environment. The effort that appears necessary to make CAI-1500 type systems operationally feasible is of such magnitude and requires expertise at such levels that it should be accomplished at educational institutions having advanced schools of education, where such expertise exists.

3. Use of the CAI-teletype system for computational techniques (problem-solving, simulation data reduction and formatting) was effective in improving the academic level of the courses involved and provided a powerful tool using techniques unavailable without the computer. It is recommended that, if this system is to be used for operational instruction, the following conditions exist:

- It is mandatory that the computer system be reliable.
- The terminal response time should be low (1-3 seconds).
- A simple, conversational computer language should be used.

4. On the basis of cost-effectiveness, CAI-teletype systems are recommended (and are being used by the military for educational purposes in most of the service academies and the senior service schools). The number and type of terminals and the software requirements can be tailored and easily changed to meet the unique requirements of each institution, military or civilian.

A P P E N D I X E S

APPENDIX A

ABSTRACTS OF ALL SUPPLEMENTS TO THIS REPORT

ABSTRACT of Supplement A - CAI-TELETYPE PROJECT REPORT

This supplement documents the CAI-Teletype Project in which standard ASR-33/35 teletypewriters were employed as remote terminals for time-sharing computing systems. The project proceeded through four one-year stages which have been labeled: spot-testing, implementation, validation, and evaluation. During the first stage the participation of faculty members in "spotting" areas of potential application was encouraged through orientation and working sessions to develop materials. In the implementation stage, faculty members used the CAI materials with full classes of students. By academic year 1967-68, various CAI techniques were employed in 12 different courses and in a special project that provided instruction in operating the cathode-ray oscilloscope. The validation stage took place during academic year 1968-69 and involved the critical analysis and revision of four courses: Aerodynamics, General Physics, Electrical Science, and Mechanics of Materials. The evaluation stage consisted of the experimental evaluation of the courses involved in the validation stage with the exception of Aerodynamics. The nature of each course, the rationale for the use of CAI, the nature of the CAI materials, and the experimental conditions and results are discussed. In addition, an analysis of attitudes, individual differences, and problems of evaluation is provided.

Beginning with a summary of results and conclusions pertaining to the various types of CAI examined in this project, the final chapter of this supplement briefly discusses the following topics: current status of CAI at the Naval Academy; analysis of events and factors leading to the growth of operational CAI at the Academy; trends in academic computer utilization at the Academy; and overall conclusions regarding CAI-Teletype costs, benefits, and areas of potential payoff.

ABSTRACT of Supplement B - DATA MANAGEMENT SUBSYSTEM REPORT

The data management subsystem (DMS) developed for support of the Naval Academy CAI-1500 project is documented in this supplement. The main body of this document concentrates on the analysis of and an approach to the problem of data management in curriculum development and educational research projects.

The description and evaluation of the Naval Academy (DMS) is written mainly with users in mind. Documentation of interest to computer specialists can be found mainly in the manuals and programs included as Appendixes.

All student performance, attitudes, and characteristic data collected during the evaluation phase of the CAI project are on file at the Naval Academy. Data file structure and record formats are documented in the Appendixes.

ABSTRACT — of Supplement C - PRODUCTION OF CAI MATERIALS

This supplement describes the approach to the production of CAI-1500 instructional materials which evolved over the course of this project.

The IBM 1500 Instructional System is discussed in terms of reliability, limitations, overall costs, and modifications made to the operating system. Topics under the major heading of manpower include: number and type of personnel, time required for programming, training manuals, and general staffing considerations. Problems encountered relating to manpower are discussed. The procedures for programmer assignment and the establishment of lines of authority are analyzed.

Conclusions are presented in terms of general development considerations relating to costs, supervision, programming standards, documentation standards, manpower requirements, and computing systems and languages. General recommendations are offered.

A B S T R A C T - of Supplement D - CAI PROJECT FACILITIES

This supplement describes and assesses the facilities used in the Naval Academy's CAI project. Standard teletype terminals accessing remote commercial time-sharing computers were employed initially for the CAI-Teletype Project. In support of other computer uses were three batch processing systems at the Academy (IBM 1620, IBM 7094, and IBM 360/30). A Honeywell (GE) 635 time-sharing system was available in-house by January 1971. Space for this equipment and student terminal classrooms is discussed.

The 1800-based IBM 1500 Instructional System was employed in the CAI-1500 Project. The components of this system are defined and their configuration is delineated. The three modes of use (student, proctor, and author) of the instructional display stations are described, with attention given to the input and output devices. Requirements for the use of the Time-Sharing Executive System (TSX), the card/paper tape programming system, FORTRAN, and the subroutine library for the 1800 version of the IBM 1500 system are outlined. The 1500 programming systems consisted of station control, station command processing, CAI processing (COURSEWRITER), CAI support, and CAI utility programs.

The operating systems available for the Honeywell (GE) 635 computing system are the Dartmouth (Phase II) Time-sharing System (DTSS), the General Electric Comprehensive Operating System (GECOS), and a GECOS simulator. Some of the languages available under DTSS and GECOS are: BASIC, ALGOL, LISP, MIXAL, FORTRAN IV, JOVIAL, COBOL, GMAP, and SIMSCRIPT.

An assessment of the suitability of the facilities used in the Naval Academy's CAI project is provided. The general performance, limitations, and costs of the 1500 and 635 computing systems as well as special modifications made are discussed. General recommendations relating to hardware and software are offered.

A B S T R A C T - of Supplement E - TECHNICAL RECOMMENDATIONS BY CONSULTANTS (2 volumes)

This supplement consists of a series of papers by two consultants -- Professors Stolurow and Brennan -- to the Naval Academy's CAI and Multi-Media projects. These consultants concentrated on issues involved in the development of self-instructional systems and evaluation. However, owing to the complex nature of the projects, they addressed themselves as well to problems touching on nearly all aspects of the Educational Systems Center's research and development program, particularly in the areas of statistics, research design, and CAI as well as behavioral and educational technology in general.

ABSTRACT - of Supplement F - FORMATIVE EVALUATION

This supplement documents the process of formative evaluation -- program revision based on student-generated data. Emphasis is directed toward the four courses developed for the CAI-1500 Project. These courses were basically tutorial and drill-and-practice and were typically of longer duration than those implemented in the CAI-Teletype Project.

Course development and revision time frames are delineated, and general revision and data collection procedures are discussed. The major problems encountered in the formative evaluation of the four courses are outlined, and the status of the course materials prior to the last implementation is given.

A brief analysis of the revision procedures employed is discussed in terms of the development of an efficient data management subsystem and the establishment of revision criteria. An approach to objectifying revision procedures is introduced, and general conclusions and recommendations are offered.

It is clear that the formative evaluation process is necessary for validating individualized instructional materials. It is also recognized that this process can be costly and time consuming.

It is essential, therefore, that a more objective approach be developed to provide decision criteria about what to revise when a self-paced instructional program fails to bring about the desired level of performance.

Further work should be done to clarify the field of criterion-referenced testing as applied to instructional programs. In addition, the use of efficiency measures, latencies, and student attitude and confidence measures as variables in the decision process should be more clearly delineated.

ABSTRACT — of Supplement G - CAI-1500 PROJECT EVALUATION REPORT

This supplement treats summative and research analyses conducted on the portions of the four courses presented via the IBM 1500 Instructional System. The basic modes of CAI employed were tutorial and drill and practice. However, the precise application of each mode varied in some degree from course to course. The fall Chemistry and Physics materials were tutorial in nature, but the former was intended to completely replace the conventional class sessions whereas the latter was to be an introduction to class sessions on specific topics. While the spring Chemistry, Naval Operations Analysis, and Russian materials all were drill and practice, they varied in the amount and type of remediation provided as well as in the specific strategy employed.

The types of analyses discussed for each of the courses relate to summative evaluations of CAI program performance and comparative evaluations of course examinations, study time, and student attitudes toward both course content and the medium of CAI. Also included are analyses of individual differences which identify students most likely to benefit on examinations or to save time through the use of CAI.

The analyses of group differences (CAI vs conventional) indicated that the CAI materials were as effective as, and in some cases superior to, comparable conventional presentations in terms of instructional outcomes relating to examination performance, time spent, and attitudes toward content and the medium of CAI. Individual difference analyses indicated that students with certain personality characteristics, attitudes, interests, and cognitive abilities would differentially benefit from the use of CAI. Instructional decision models employed with the various modes of CAI should be sophisticated enough to take these individual differences into account if the full potential of CAI is to be realized.

ABSTRACT – of Supplement H – CAI-1500 CHEMISTRY COURSE REPORT

This supplement documents the development and evaluation of the General Chemistry material implemented via the IBM 1500 Instructional System. Developmental aspects including organizational and manpower requirements from the initial efforts in 1967 to the final course implementaion in 1971 are discussed.

The instructional hardware and software utilized are outlined and samples of the instructional materials are provided. Course objectives, flowcharts, COURSEWRITER II documentation, and student comments are presented in the appendixes.

The evaluation data covers the last implementation conducted during the 1970-71 academic year. CAI program performance and performance on administrative examinations as well as time and student attitudes are assessed. Conclusions and recommendations are offered.

ABSTRACT — of Supplement I - CAI-1500 RUSSIAN COURSE REPORT

This supplement documents the development and evaluation of the Basic Russian material implemented via the IBM 1500 Instructional System. Developmental aspects including organizational and manpower requirements from the initial efforts in 1968 to the final course implementation in 1971 are discussed.

The instructional hardware and software utilized are outlined and samples of the instructional materials are provided. Course objectives, COURSEWRITER II documentation, and student comments are presented in the appendixes.

The evaluation data covers the last implementation conducted during the 1970-71 academic year. CAI program performance and performance on administrative examinations as well as time and student attitudes are assessed. Conclusions and recommendations are offered.

ABSTRACT — of Supplement J - CAI-1500 NAVAL OPERATIONS ANALYSIS COURSE REPORT

This supplement documents the development and evaluation of the Naval Operations Analysis material implemented via the IBM 1500 Instructional System. Developmental aspects including organizational and manpower requirements from the initial efforts in 1968 to the final course implementation in 1971 are discussed.

The instructional hardware and software utilized are outlined and samples of the instructional materials are provided. Course objectives, flowcharts, COURSEWRITER II documentation, and student comments are presented in the appendixes.

The evaluation data covers the last implementation conducted during the 1970-71 academic year. CAI program performance and performance on administrative examinations as well as time and student attitudes are assessed. Conclusions and recommendations are offered.

ABSTRACT — of Supplement K - CAI-1500 MODERN PHYSICS COURSE REPORT

This supplement documents the development and evaluation of the Modern Physics material implemented via the IBM 1500 Instructional System. Developmental aspects including organizational and manpower requirements from the initial efforts in 1967 to the final course implementation in 1971 are discussed.

The instructional hardware and software utilized are outlined and smaples of the instructional materials are provided. Course objectives, COURSEWRITER II documentation, and student comments are presented in the appendixes.

The evaluation data covers the last implementation conducted during the 1970-71 academic year. CAI program performance and performance on administrative examinations as well as time and student attitudes are assessed. Conclusions and recommendations are offered.

APPENDIX B

LIST OF MEMBERS, NAVAL ACADEMY CAI ADVISORY BOARD

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APPENDIX C

LIST OF NAVAL ACADEMY PARTICIPANTS IN THE CAI PROJECTS

<u>CAI-TELETYPE COURSES AND INSTRUCTIONS</u>

Course		Instructor	Still at USNA
E210	Mechanics of Materials	LCDR D. B. Reynolds	
		LCDR B. W. Welles	
		H. B. DeMart	X
E405	Fluid Mechanics II	R. F. Latham	X
E408	Thermodynamics II	R. F. Latham	X
E631	Introduction to Aerodynamics	R. D. Mathieu	X
E708	Heat Transfer I	J. A. Adams	X
E710	Reactor Physics	W. F. Eckley	X
E732	Aerodynamics I	R. D. Mathieu	X
E735(L)	Aero Performance	CDR D. W. Mathews	
E810	Reactor Kinetics	W. F. Eckley	X
E832	Aerodynamics II	D. F. Rogers	X
		C. O. Heller	
E836	Aerospace Design	C. O. Heller	
		D. F. Rogers	X
		B. H. Carson	X
E924	Advanced Topics in Aerospace Engineering	C. O Heller	
		V. V. Utgoff	X
N315/N316	NavOps I and II	P. M. Tullier	
N318	NavOps (Demo only)	G. B. Hannah	X
S102	Chemistry	LT J. L. Koontz	
S211/212	General Physics	LCDR John Kropf	
		LT Anton Vierling	
		CAPT John Jones, USMC	X
S305/306	Electrical Science	J. L. Daley	
		C. A. Fowler	X
		W. K. Kay	X
		E. J. Eberhardt	X
		R. P. Santoro	X
S704	Computer Aided Underwater Acoustics	S. A. Elder	X
W931	Weapons Systems	D. F. Haber	
	Oscilloscope Operation	A. E. Conord	X

CAI-1500 COURSES AND INSTRUCTORS

Course	Instructor	Still at USNA
(S206) SP301 Modern Physics	E. A. Hall	X
	LCDR J. Kropf	
	D. A. Nordling	X
	F. L. Miller	X
FR101/FR102 Basic Russian	*C. P. Lemieux	X
	K. E. Lappin	X
	H. R. Keller	
NA311 Naval Operations Analysis	*CDR R. M. Olsen	X
	*LCDR D. J. Kenney	X
	*LCDR C. E. Peterson	X
	G. B. Hannah	X
	LTJG T. L. Sopwith	
	LT J. H. Reed	
SC114 General Chemistry	LT P. A. Boudreau	X
	LTJG W. L. Mohr	X
	*ENS J. B. Flanegan	X
	*J. H. Klein	X
	*W. M. Smedley	X
	*MAJ R. F. Larriva, USMC	X
	*CDR R. W. Sirch	X
	LTJG M. Deverell	
	LT E. Dabich	
	LCDR Patrick McKinnon	
	LT David McCaffrey	
Miscellaneous and Special Projects	LCDR Markham Tuft	
	W. Geatches	
	R. Driftmeyer	
	K. F. Read	X
	Chih Wu	X
	W. M. Lee	X
	MAJ R. Gulick	
	D. F. Haber	
	E. E. Betz	X

*Administrator, not author